SEPTEMBER 1955

Journal

VOL. 47 • NO. 9

AMERICAN WATER WORKS ASSOCIATION

In this issue

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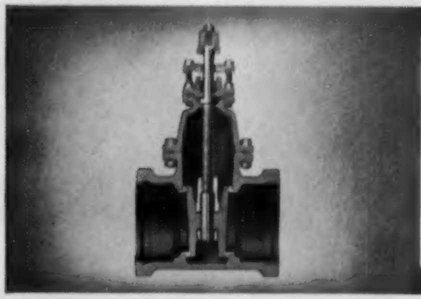

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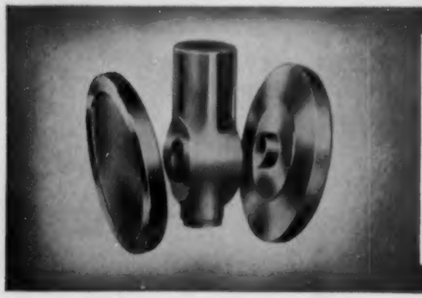

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Contents

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Coming Meetings

AWWA ANNUAL CONFERENCE

May 6–11, 1956, at St. Louis, Mo. Members' reservation blanks will be mailed after Nov. 1, 1955.

AWWA SECTIONS

Sep. 25–27—Missouri Section at the Connor Hotel, Joplin, Mo. Secretary, W. A. Kramer, Room 3, 6th Floor State Office Bldg., Jefferson City, Mo.

Oct. 5–7—North Central Section at Radisson Hotel, Minneapolis, Minn. Secretary, Leonard N. Thompson, Gen. Mgr., Water Dept., St. Paul 2, Minn.

Oct. 16–19—Southwest Section at Gunter Hotel, San Antonio, Tex. Secretary, Leslie A. Jackson, Mgr.-Engr., Munic. Water Works, Robinson Memorial Auditorium, Little Rock, Ark.

Oct. 17–18—Canadian Section, Maritime Branch, at Isle Royale Hotel, Sydney, N.S. Secretary, J. D. Kline, Box 608, Halifax, N.S.

Oct. 19–21—Iowa Section at Hotel Fort Des Moines, Des Moines. Secretary, H. V. Pedersen, Supt., Water Works, Munic. Bldg., Marshalltown.

Oct. 20–21—West Virginia Section at Waldo Hotel, Clarksburg. Secretary, Harry K. Gidley, Director, Div. of San. Eng., State Health Dept., Charlestown.

Oct. 20–22—New Jersey Section at Hotel Madison, Atlantic City. Secretary, C. B. Tygert, Wallace & Tiernan Inc., Box 178, Newark 1.

Oct. 25–28—California Section, at Senator Hotel, Sacramento. Secretary, H. F. Jerauld, Asst. Supt., Constr. & Operation, Water Dept., 1040 Manzanita Ave., Pasadena 3.

Oct. 26–28—Chesapeake Section, at Sheraton Park Hotel, Washington, D.C. Secretary, Carl J. Lauter, 6955—33rd St., Washington 15, D.C.

Oct. 30–Nov. 2—Alabama-Mississippi Section, at Buena Vista Hotel, Biloxi, Miss. Secretary, Charles W. White, Asst. San. Engr., State Dept. of Public Health, 537 Dexter Ave., Montgomery 4, Ala.

Nov. 3–5—Virginia Section, at Hotel Roanoke, Roanoke. Secretary, J. P. Kavanaugh, 213 Carlton Terrace Bldg., Roanoke 11.

Nov. 6–9—Florida Section, at Orange Court Hotel, Orlando. Secretary, Harvey T. Skaggs, Secy. & Gen. Mgr., Amica Burnett Chem. Co., Box 2328, Jacksonville.

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Coming Meetings

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Nov. 14–16—North Carolina Section, at Robert E. Lee Hotel, Winston-Salem. Secretary, W. E. Long Jr., 1615 Bickett Blvd., Raleigh.

OTHER ORGANIZATIONS

Sep. 21–23—Georgia Water and Sewage School, at Hightower Textile Bldg., Georgia Inst. of Technology, Atlanta.

Oct. 10–13—Federation of Sewage & Industrial Wastes Assns., at Ambassador Hotel, Atlantic City, N.J.

Oct. 14-15—National Society of Professional Engineers, at Peabody Hotel, Memphis, Tenn.

Oct. 17-21—National Safety Congress and Exposition, at Conrad Hilton Hotel, Chicago, sponsored by National Safety Council. Secretary, R. L. Forney, 425 N. Michigan Ave., Chicago 11, Ill.

Oct. 22-31—International Congress of Industrial Chemistry, Madrid, Spain. Secretariat, Serrano, 150, Madrid.

Oct. 23-26—Pennsylvania Municipal Authorities Assn., at Bellevue-Stratford Hotel, Philadelphia.

Oct. 24–28—American Society of Civil Engineers Convention, at Hotel Statler, New York.

Oct. 24–26—National Conference on Standards, at Sheraton Park Hotel, Washington, D.C., sponsored by National Bureau of Standards and American Standards Assn.

Nov. 1–3—Panel Conference on Underground Structure Corrosion, at Hotel Niagara Falls, N.Y., sponsored by Northeast Region, National Assn. of Corrosion Engrs.

Nov. 14–18—American Public Health Assn. Convention, at Municipal Auditorium, Kansas City, Mo.

Nov. 16–18—Water Works Management Short Course, at Univ. of Illinois, Allerton Park, Ill.

Nov. 27–30—American Institute of Chemical Engineers, at Hotel Statler, Detroit, Mich.

Nov. 27–30—National Chemical Exposition, at Public Auditorium, Cleveland, Ohio, sponsored by Chicago and Cleveland sections, American Chemical Society.

Dec. 5–9—Exposition of Chemical Industries, at Commercial Museum and Convention Hall, Philadelphia, Pa., under management of International Exposition Co., New York.

Dec. 11–17—Nuclear Engineering and Science Congress, Cleveland, Ohio, sponsored by Engineers Joint Council.

1956

Feb. 13–18—Symposium on Winter Concreting Theory and Practice, International Union of Testing & Research Labs. for Materials & Structures (RILEM), Copenhagen, Denmark. Organizing Secy., RILEM Symposium 1956, c/o Danish National Inst. of Building Research, 20 Borgergade, Copenhagen, K, Denmark.

Jun. 17-23—World Power Conference, Vienna, Austria. Oesterreichisches Nationalkomitee der Weltkraftkonferenz, Vienna I, Schwarzenbergplatz 1.


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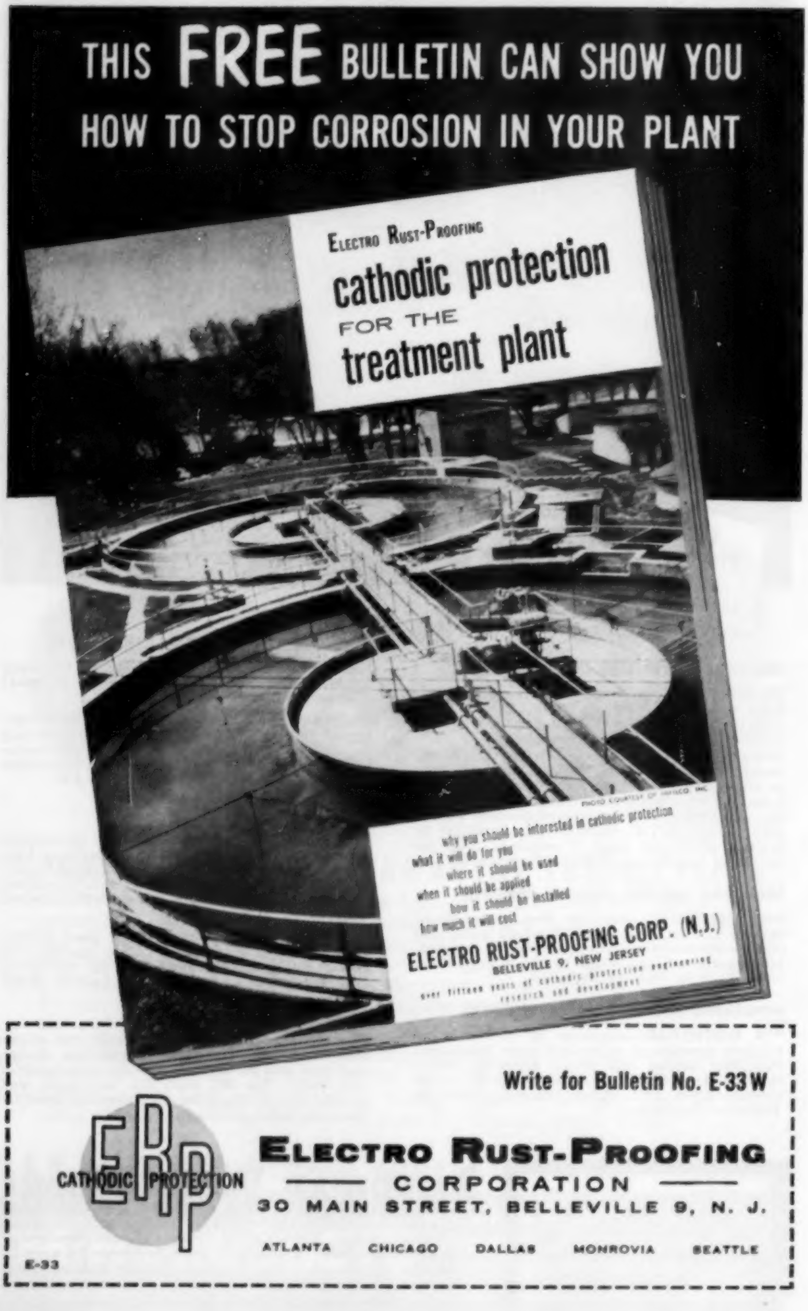
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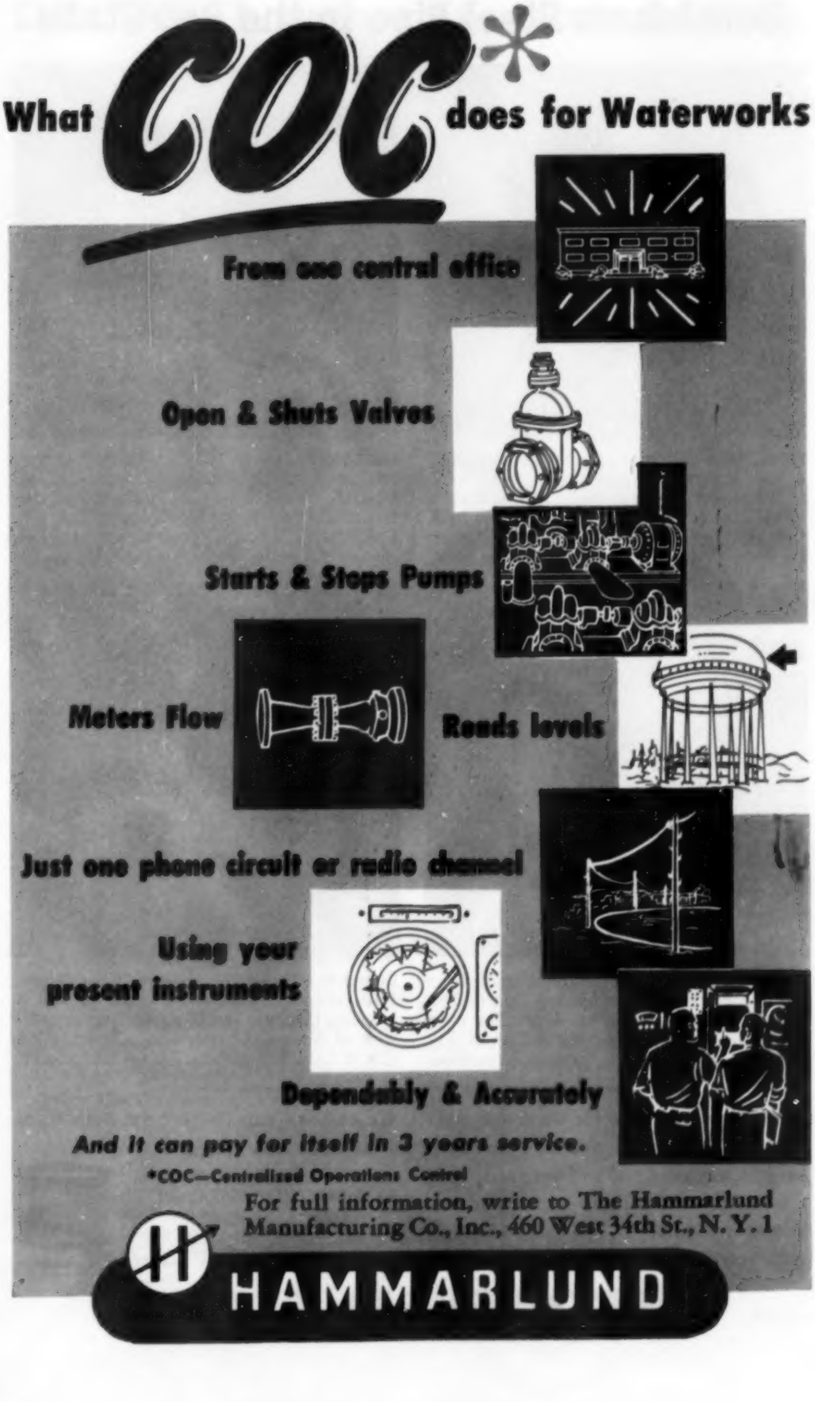
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Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 47 • SEPTEMBER 1955 • NO. 9

Our National Water Resources Policy

Clarence A. Davis

An address presented on Jun. 13, 1955, at the Annual Conference, Chicago, Ill., by Clarence A. Davis, Undersecretary, US Dept. of the Interior.

I AM sure the subject, "Our National Water Resources Policy," is a noncontroversial one! If you don't believe that, read the *Congressional Record* most any morning. In fact, one of your leading members recently sent me a pair of asbestos gloves which he was sure I would need to handle this hot potato!

Last February when I was invited to speak, it was thought that by this time the President's advisory committee on national water policy would have made public a report which could be the subject of my discussion with you today. Unfortunately, that committee has not yet presented its report and, I am sure therefore, you will understand that I cannot discuss it.

That is no reason, however, why I should not discuss some of the water problems of the country and state some views regarding them, because, as you know, these problems have been very widely discussed by many great national organizations for years. Quite a few of these organizations have themselves adopted what they believe to be adequate policy statements on the subject. Some of these groups are the Engineers Joint Council, the National Reclamation Assn., the US Chamber of Commerce, and the American Farm Bureau Federation. There are many others.

The most interesting part of the water problem to me has been that there is not really much difference between the recommendations of all of these organizations as far as the fundamental things that need to be considered. The points on which the groups agree are more numerous than the ones on which they differ. What I should like to impress most upon the minds of all of us, though, is the fact that there is no single water problem in the United States; that there are a

multitude of problems; and that they are nationwide, though not necessarily "national," in scope. I should like to impress on you that many of the problems are of state and local nature, but they are just as acute and require just as much thought and attention as do some of the more spectacular, so-called, "national" problems.

It has not been so many years since there was a tendency to place at the head of the list of water policies, as the most important of them all, the control and development of our great river basins, coupled, in most part, with that vote-baiting phrase "cheap hydroelectric power." I think all of us are now aware that we have tremendous water problems quite disassociated from the major river controls: a problem of stream pollution which is growing alarmingly in many parts of the country; great problems relating to our underground water, about which we do not know as much as we should; and great problems relating to adequate water supplies for growing population and industrial centers. We should also be aware that we have substantial possibilities of working toward a solution of our water problem, as well as of problems of erosion and land protection, all of which are quite apart from the big river–big dam conception which was so long regarded as the answer to all water problems. This is good, because it approaches the water problem on a broad front, rather than upon that of a narrow, semipolitical one. The conception that any one dam or any two or three major and spectacular structures can be any answer to the broad water problems of the United States is, I am sure, a conception that dominates the minds of some politicians and not the minds of those familiar with the problems of water.

US Dept. of the Interior

Most of you here are primarily engaged in the problem of water supply and distribution. The US Dept. of the Interior, which I have the honor to represent, is probably the largest water-distributing agency in the United States. Over the half century of its existence it has developed about 7,000,000 acres of irrigated lands for which it provides water. Let us not overemphasize this total, however, for it represents only one-fourth of the irrigated acreage of the United States, the other three-fourths' having been developed by local interests without federal aid.

In the course of its developmental activities, the Dept. of the Interior has constructed numerous hydroelectric works and is also the marketing agency of hydroelectric energy from dams constructed by the US Corps of Engineers. It is now the distributor of approximately 12 per cent of the electric energy of the United States. Through the years, the program of reclamation has turned millions of acres of desert into highly fertile fields. The result of its program has been the creation of good farms, nice homes, prosperous cities and a profitable economy for dozens of areas in the United States. We may call these secondary benefits and we may ignore them in our mathematical computation of benefit–cost ratios. Perhaps they have had no more effect on the national economy than would the expenditure of similar sums have had elsewhere, but, at any rate, they give us tangible evidence of what man can do, and has done, by the intelligent application of water.

Need for Water Survey

There is no doubt that we have reached the time when an adequate

survey of the whole water resource problem is appropriate. The years since World War II have illuminated the fact that water is the one basic resource upon which all else depends, and this fact, fortunately, is becoming widely recognized by citizens generally, as well as by you who are daily confronted with the problem.

I can summarize quickly by saying that in many areas of the United States we are for the first time experiencing water shortages. We are beginning to find that underground water in many places is exhaustible. We are finding that there is a limit to which we can pollute our streams, either by municipal or industrial waste. And we are finding that the industrial demands for water are almost beyond comprehension. We are finding that adequate water supplies in many cases are more determinative of the location of new industry than are electric rates, freight rates, or even raw materials. We are foreseeing inherent conflicts in the water resource problem that, as years go on, will really become "hot potatoes."

As populations and industrial uses climb, within some areas the temptations toward water diversion and grave injustices to prior existing uses will grow more intense, and we will further find that turning to the federal government is not the solution to all our problems. We have had federal activity in the field of water resources from the beginning of our country. The Corps of Engineers, with its program of the improvements of rivers and harbors, is almost as old as the United States, although the transfer of its activities upstream, where no navigation in fact is involved, is much more recent in origin. The US Bureau of Reclamation is 53 years old, but it is dedicated primarily to the seventeen western states, and, by law at least, its activities are directed toward the reclamation to fertility of the arid and semiarid lands of the West. It, too, has expanded its activities into other fields. The US Soil Conservation Service has been with us for many years, but the new program of the Dept. of Agriculture, under the recent Watershed Development Acts, as yet in the formative stages, bids fair to attack not only the water problem, but also the soil conservation problem from an entirely new concept. The US Dept. of Health, Education, and Welfare has substantial activities in the field of municipal and industrial water supplies and pollution, but has so far not found it necessary to exert all of the power with which it is vested to solve some of the problems involved.

Need for Confidence

Despite the passage of coordination acts and repeated adjurations of the Congress, I feel that we are still too much in pursuit of special programs of particular agencies without adequate coordination; and I think it is no great secret that, in the past, there have been frequent conflicts and jealousies between the groups operating in this field. It seems to me that a great weakness has been the rather narrow characteristic of many of our water proposals and the failure to recognize and to utilize adequately the tremendous reservoir of strength which is represented by local areas and by persons outside of government.

We have not adequately drawn into our plans and our projects many of the resources of communities and technicians which are available to us. I think we must recognize that there has been, and still is, criticism that unsound projects have been fostered by federal agencies. Whether that criti-

cism is justifiable or not, some of you gentlemen are in a much better position to judge than I. I do know that, because of that criticism, there is not the widespread public confidence in many of these projects that there should be if the project is sound and if we are to proceed with the development. This is, I think, best evidenced by the fact that in the water program of substantially every organization of which I know—and that comprises most of the more important—there is a recommendation that federal projects should not be submitted to the Congress until they have had a complete review by an independent board of engineers and other specialists to evaluate their engineering and economic feasibility, particularly with reference to their potentialities for repayment.

It is not wholesome that the criticism evidenced by these resolutions and declarations is being made. We ought somehow to be sure that our projects are in the public interest and are beyond dispute as to fundamental engineering and financial facts. This again emphasizes the fact that in many of these proposals we have not had the broad base of popular local support and confidence that is so necessary if we are to proceed intelligently with a water resources program. Any plan which will eliminate these criticisms—or suspicions if you prefer—and will bring about unanimity of thought, not only among federal agencies but among the local people who are vitally interested, is, beyond question, one of the most desirable objectives.

Local Participation

Another situation which continues to evoke more and more attention is the substantial difference between water resources programs as far as local participation and local contribution toward benefits received are concerned. Our present programs vary widely, all the way from those in which local people and benefited areas are required to make full repayment with interest to the other extreme, where almost no local contribution is required. I certainly shall not undertake to solve that problem or even to discuss it, but I point it out to you as one which is clearly apparent to anyone surveying governmental activities in the field of water policy.

Another problem which I have frequently discussed is the problem of laws relating to water. We vary across this country from the doctrine of appropriation on the one side to that of riparian rights on the other, with innumerable modifications of both in the various states. This is a problem into which I have felt the federal government should not materially intrude itself. The differences in climate, in water supply, and in water use are so varied, and the need for the recognition of different rights in different places is so apparent that any adaptation of water to its maximum beneficial use must necessarily require varied legal regulations. It seems to me this is a field in which water policy must be locally determined.

There are some other activities relating to water which some of you have heard me discuss before, but which I think are worthy of mention. The first of these is underground waters—and that problem leads me directly into the subject of basic data.

Underground Supplies

We are a relatively young country, especially in the West, and we are discovering some areas in which our utilization of underground water supplies

is vastly exceeding their restoration. There are other areas in which it is safe to say that even our scientists have been surprised at the apparently inexhaustible water supplies beneath the surface. I think the US Geological Survey is recognized as one of the outstanding scientific organizations in the world—perhaps the finest—but even the Survey has had neither the time nor the money available to carry through many of its programs, which are becoming more and more important to an intelligent approach to some of these problems.

Likewise, I have pointed out that many of our states have so far made no attempt to assert any controls or regulation of underground waters. But problems are arising: Can we tap these underground waters and carry them away to areas other than the land surface which covers them? Can we permit a drawdown to continue without limitation, once it becomes apparent that the ultimate effect is apt to be disastrous? Much as I disbelieve in governmental interference until it becomes essential, I cannot help but wonder if many of our states are not permitting to develop without regulation a situation which will greatly intensify the problems they will face in the years to come.

Salt Water Demineralization

Like everyone else, I suppose, I have been intensely interested in the program of the Dept. of the Interior on the demineralization of saline water. I suppose many of you are much more familiar with the problem than I, but for those of you who are not, let me say that progress is being made. The Dept. of the Interior has been engaged for several years, in consultation with the National Science Foundation and various other government departments and agencies, in a program endeavoring to find some process for the demineralization of water by a method that will deliver substantial quantities at a cost which is within the reach of our economic, agricultural, and industrial potentials. The department has had $400,000 a year available for that program and, under the direction of Congress, the research has been handled largely by the method of grants to colleges and scientific and industrial organizations, in an endeavor to put to work some of the best scientific brains of the country.

Much progress has been made. The original goals have already been exceeded and though the costs are still in excess of an amount which we would like to pay and still far too high for a competitive industry or for agricultural use, they are coming at least within sight of limited domestic use. We are at a point where the initial cost of energy in the process is about 12 cents per thousand gallons and where investment and operational costs will probably double that figure. But the studies in possible use of solar energy, wind power, and geothermal energy, as well as conventional electric power, are sure to bring that cost down. The groups involved are continuing to work, and if the past achievements of American scientists and industrialists are any indication, they may yet evolve a process which will solve the problem.

I need hardly point out to you the almost unbelievable effects that such a program, if successful, would have upon the world with its millions of acres of land that would be fertile with adequate water, with its millions of people not adequately fed, and with its relatively low productive capacity. The possibilities are limited only by our imagination.

Weather Control

The other fascinating subject, which is still in the embryonic stage, is the study of the potentialities of weather modification. On this matter, even our best scientific minds are reluctant to express opinions. The scattered information, the potentiality of coincidences, coupled with known facts regarding possibilities, make any definite prophecies unrealistic. All that can be said is that weather modification is a potentiality recognized, I understand, by the laws of eleven states, and one that is being studied not only in the United States, but also all over the world as a means of the partial control of water supplies.

This brings me back to the text from which I have preached numerous sermons. A water policy must not confine itself merely to municipal water supplies, nor to the control of floods, nor to the irrigation of land, nor to the control of pollution. It must be broad and comprehensive; it must consider all of these problems as a unified part of a program of the development of water resources. The amounts of money required stagger the imagination. We are told that it requires at least $200,000,000 a year to keep abreast of the hydroelectric requirements in the Columbia Basin; we are told that it takes $150,000,000 a year merely to keep abreast of the growth of the Tennessee Valley Authority; we are told that it requires about $750,000,000 a year to keep abreast of the problem of stream pollution. I do not have the figures, but we realize that there are hundreds of millions of dollars required annually in the field of municipal water supplies. The control of our floods and the development of our rivers and harbors could easily absorb another $700,000,000 a year, and this is not to discuss in any manner the additional millions needed to bring many of these services to the benefit of the individual user.

Full Participation

This program, therefore, cannot be and should not be exclusively a federal program. The municipalities, the states, and their agencies have available almost unlimited sources of capital at interest rates no greater, and sometimes much less, than that of the federal government itself. For that reason we have been urging the widest participation in the water program by all levels of government, by all agencies, by private individuals and corporations—not only that they may bear a portion of the costs from which they directly benefit, but also that they may exercise a more potent voice in the solution of their problems. I have said repeatedly that not all wisdom reposes in the District of Columbia. Much of it relating to this problem reposes in this very audience which I am addressing, and the participation and cooperation of all of you will make a great contribution toward solution of the water resources problem—the great problem of the country in the years that lie ahead.

Regional Water Supply Planning for Northern Ohio

Paul Belcher

A paper presented on Jun. 13, 1955, at the Annual Conference, Chicago, Ill., by Paul Belcher, Vice-Pres., First National Bank of Akron, Akron, Ohio.

MORE than 40 years ago, the Ohio Legislature granted Akron the exclusive right to develop the water supply of the upper reaches of the Cuyahoga River—a watershed comprising 207 sq miles. Immediately afterwards, the city started work on Lake Rockwell, an impounding reservoir formed by a hollow concrete dam located about 2½ miles northeast of Kent, Ohio, 280 ft in length, with a crest elevation 1,052 ft above sea level and 480 ft above Lake Erie. The reservoir has a water surface of 769 acres and an available capacity of 2.3 bil gal. Each spring, flashboards, 18 in. high, are placed along the crest of the dam, thus obtaining an additional 400,000,000 gal.

A second artificial lake, East Branch Reservoir, located in the Cuyahoga watershed northeast of Burton, Ohio, was created by an earthen dam with concrete spillway at an elevation of 1,132 ft above sea level. This reservoir covers 420 acres, providing an available storage capacity of 1.5 bil gal.

The land for a third reservoir in the watershed is now being acquired. When the artificial lake has been completed, the possibility of constructing two more impounding reservoirs within the watershed will remain. If developed, one would be considerably larger than any now in existence or in progress.

Although the upper Cuyahoga River can provide sufficient water throughout the year to supply the present needs of a city as large as Cleveland, the rapid population increase expected in the Akron area, combined with the increased per capita use of water now taking place, will probably require an even larger source of supply. When the Cuyahoga watershed has been developed to the fullest extent economically advisable, the next step, according to water engineers, will be to extend a pipeline into Lake Erie. The Cuyahoga watershed is admirably suited to such a pipeline, for the Cuyahoga River originates in Geauga County, approximately 15 miles southeast of Lake Erie, flows toward Akron, and then empties into Lake Erie at Cleveland. A pipeline need be only about 15 miles long. Raw water could be pumped from the lake into the Cuyahoga River as needed to keep the reservoirs filled or to maintain an essential minimal flow of water in the river itself. After the water from Lake Erie had been lifted 550 ft to the river, gravity and Akron's existing water system would carry it the rest of the way.

Pipeline Planning

Although it is obvious that Akron can get along very well now without a pipeline to the Great Lakes, public discussion on the matter is being fostered at this time, first because planning must be done years in advance of necessity, and, second, because the public must be sold on an idea when they are receptive to it. The countrywide water shortages of the last few years have created the proper environment for this undertaking. The Lake Erie Watershed Conservation Foundation, Inc., a nonprofit organization, will spearhead the task of public education about pipelines. In addition, the foundation plans to sponsor all required preliminary engineering studies. These will be made for the common benefit of eight or nine counties in northeastern Ohio, some of which are within and some of which are without the Cuyahoga watershed, but all of which are within the Lake Erie Basin. It would be possible to supply all of these counties with water from Lake Erie by tapping Akron's pipeline. Each county, alone or in combination with others, could, of course, construct its own pipeline. If such a procedure would be the desirable thing to do, the studies might be expected to indicate it.

It is the author's belief that laymen, including himself, should look to the professionals for leadership while helping them to reach the desired goals. Laymen can often say and do things the professionals are not in position to initiate or to emphasize repeatedly. Before volunteering such assistance, the laymen must be properly educated if they are to do the cause of adequate water development good instead of harm. The water experts must be willing to teach the laymen so that they do not get their information from well intentioned, but uninformed, persons.

Two potential problems seem to be inherent in the water utility field: adequate distribution and sufficient water supply. If either one fails to meet the demands of consumers, king-sized headaches often result. Time and money can usually correct all troubles caused by inadequate distribution facilities. Insufficient water supplies, however, often present basic problems incapable of such solution. Many communities are dependent upon the available surface and ground water. Others are able to tap principal rivers and fresh water lakes because of their proximity.

Resources of Great Lakes

No area in the United States is more highly favored in the matter of supply than the watershed of the Great Lakes. These natural reservoirs are capable of supplying indefinitely the needs of all future inhabitants of the Great Lakes Basin, including all possible industrial activities. No other section can approach this inexhaustible attribute of the Great Lakes region until it is learned how to obtain fresh water from the sea in adequate quantities without prohibitive expense. Meanwhile, most cities must depend on rainfall and its conservation for filling water requirements. Ground water, of course, originates from rainfall, too, somewhere at some time.

A growing population is demanding more water, a trend evident everywhere in both domestic and industrial water consumption. Air conditioning is now presenting many water utilities with problems. Water, an essential

raw material for practically every industrial operation, is required in huge amounts for chemical manufacture, smelting, paper making, producing electricity, and numerous other activities.

Under present water laws, everyone must ordinarily satisfy his needs from his own watershed or water system; from a practical standpoint, there is seldom anywhere else to go. Although arbitrary political lines, such as city or county boundaries, no longer designate satisfactory water distribution areas, cities often possess vested rights in the only existing water supplies. Such municipalities must eventually serve all water needs within their watersheds or risk being stripped of their exclusive water rights. Water should be sold to everyone willing to pay for it. Where possible, price should do the rationing. If appropriate legislation must first be enacted, or constitutional changes be made, careful study is necessary to determine exactly what should be done. In Ohio, for instance, a constitutional provision restricts the amount of water a city can sell to water users outside the corporate limits to one-third of all water distributed. That provision must be revoked before Akron can fulfill its obligation to all water users within the Cuyahoga watershed.

When all possible uses of water cannot be met from an available supply, the uses must be classified, so that the most essential are given the highest priorities. Water utilities, both publicly and privately owned, must anticipate the needs of prospective watershed customers and, where possible, must keep supplies well ahead of such requirements.

In many parts of the United States development of water supplies has definite limitations. Because no one can conserve or use more water than nature provides, economic growth must be restricted in such areas.

Fortunately, no city located in the watershed of the Great Lakes need face such a future. Each municipality has the means of ascertaining how it can tap one of the lakes and how much it will cost. Most towns already have authority to act on the matter. Such simple recourse applies only to communities that can put the used water back into the same watershed from which the raw water was taken, because diversion from one watershed to another is a different affair. Cities that want to take water from the Great Lakes and discharge it into the Ohio or the Mississippi must obtain Congressional approval and, probably, a change in the treaty on this subject between the United States and Canada.

Conclusions

The author has no interest in calling upon the federal or state government to do for Akron what the city can do for itself. Modern water laws are needed, but the city does not want to transfer its rights to a powerful watershed district, state or federal, in which it would have little or no voice. Akron recognizes that its position in the Cuyahoga watershed and its vested water rights, as presently developed and as capable of being developed, make it imperative to supply water to all persons on the watershed who must look to Akron's source of water for their needs. If water is denied to people and industries having no other place from which to secure it, Akron would be risking divestment of its rights by the legislature.

Water is a necessity of commerce, industry, and life. Every city in the Great Lakes watershed that would take advantage of the economic opportunities of the coming St. Lawrence Seaway should insure itself an adequate water supply without further delay. For many communties within subsidiary contributory watersheds, such a procedure could be a cooperative effort. An adequate water supply, regardless of cost, must precede the influx of new industries or even of great expansion of existing operations. Industry can and will go where necessary facilities are already available.

Akron is now engaged in developing to the fullest extent economically feasible the rainfall that is deposited in the upper Cuyahoga watershed. Maximum development of all other lakes and reservoirs, as well as surface and ground water, is also under way. When these undertakings have been completed, Akron's first pipeline will surely be extended into Lake Erie. The several projects involved will be complementary to one another. Everyone in the entire Cuyahoga watershed will be the ultimate beneficiary of these enterprises.

Discussion

Wendell R. LaDue

Chief Engr. & Supt., Bureau of Water Supply, Akron, Ohio.

In a recent article about Ohio (*1*), Bentz Plagemann said:

> Ohio—the All-American State, where virtue is enshrined, where the great middle class is royalty, and the good abundant life is part of the heritage.
>
> Ohio is the state of middle dreams, the state of normalcy. Ohio is neither East nor West nor South. It just sits where it is, and never shouts to make itself heard—it just speaks on in its calm, flat, unregional, unaccented, uninflected voice. But what Ohio says in that voice, and what it has said in the past, has affected you, for better or for worse, and even whether you like it or not.
>
> The bounty of Lake Erie presses down on the top of Ohio, and the state bends with its weight, and at the bottom, the river flows, the Beautiful Ohio, where the moonlight glows, where the barges float by carrying the hard-earned wealth down to the great Mississippi. Ohio stands straight between its straight borders, plain and full of common sense.
>
> Let us take as our point of departure Sandusky, that port west of Cleveland on Lake Erie. If you know New England it will seem familiar to you, but in spite of the familiar names there is something alien to New England here, and suddenly you know what it is. This is *fresh* water, this vast inland sea stretching away to the horizon, and instead of the taste of salt in the air there is a clear, cool, woodland scent.*

In quite a different vein appeared an advertisement (*2*) of the Cleveland Electric Illuminating Co., part of which follows:

> St. Lawrence Seaway makes possible—in northern Ohio—plant opportunities never before equaled in America. The best location in the nation is now better than ever! With the St. Lawrence Seaway, a long-time dream of industry is now about to come true. For the first time in history, industries will be able to have the advantages of a "heart land" location—in the midst of the nation's greatest markets and resources—combined with low-cost ocean shipping to or

from anywhere in the world! Within a 500-mile radius of this northeast Ohio area (this new frontier of opportunity) are over half the people in the country—eleven of America's fifteen largest cities. At hand, or within a short haul, are most of the basic materials of industry—fresh water, coal, iron, salt, limestone, and many others. . . . With the Seaway scheduled for completion in five years, the time to plan for plant location along Ohio's "Seaway Shore" is during the coming year.

In the report of the Mississippi Valley Committee of 1934 appears this quotation: "Make no little plans. They have no magic to stir men's souls." Northern Ohio is not making little plans. In fact, its present thinking about water supply is stirring men's souls by its magnitude, vision, and daring. Plainly speaking, the economy of the Lake Erie watershed in northern Ohio requires more water than is now available for development unless Lake Erie is used as a primary source. Equally plain and painfully apparent is the fact that water supplies must be planned and developed to meet future growth, or water shortages of the past will appear mild by comparison.

Need for Regional Approach

A regional approach is obviously necessary. It has been said that the entire Atlantic seaboard from New England to Virginia is in reality one regional population mass, requiring a coordinated, cooperative water supply effort. A similar, though smaller area, is the south shore of Lake Erie, from Buffalo, Erie, Cleveland, and Toledo to Detroit. The Lake Erie watershed in northern Ohio, comprising about 12,000 sq miles is considered the most valuable asset of Ohio's water resources. This section, only 29 per cent of the state, contains 3,250,000 people, or 41 per cent of the state's inhabitants. Ohio possesses 3,540 sq miles of the 4,990 sq miles of Lake Erie in the United States. By volume Lake Erie would make ten Lake Meads and would require 2½ years to fill at a conservative inflow of more than 200,000 cfs, or 130 bgd. Consider the import of 130 bil gal passing into the lake each day. Compare this amount with the area's present estimated extremely high use of 1,300 gal per capita per day, or a total of 4 bil gal. There can be no thought of water shortage in any part of northern Ohio, where no area is more than 100 miles from the lake front and where the bulk of that territory lies within less than 50 miles. The problem is largely one of delivering the supply with economy and efficiency. Water, although a low-priced commodity, is an indispensable item, so much so that any effort is justified to provide it. Many sections of the United States have gone far greater distances at much more expense than Ohio must.

Legitimate Uses of Water

These are the legitimate uses of water in Ohio:

1. *Domestic and industrial consumption* represents the orderly and functional activities of a community in providing its people and its industries with a basic requirement.

2. *Production of food* may appear to fall only within the scope of a highly developed commercial farming area, but in northern Ohio there are many acres of farmland which demand large volumes of water at critical times in the growing period. Further, water used in the processing and packaging of food often produces waste difficult

to handle, yet which may legitimately be discharged into a body of water. Not to be overlooked, commercial fisheries in Lake Erie deliver tons of edible fish yearly to northern Ohio communities.

3. *Wastes disposal* is a use of water which, if not properly controlled, could result in an obnoxious situation. Sanitary engineers know waste disposal can be controlled at a cost legitimately chargeable against the producer, who may be an industry or group of industries, a city or group of cities, or large domestic and agricultural areas.

4. *Recreational pursuits* on Lake Erie and its contributory streams include fishing, boating, canoeing, sailing, bathing, waterfowl hunting, and water sports. Lake Erie's shores and its streams are dotted with summer residences for individual families and recreational areas for large groups.

5. *Production of power and cooling* is represented almost entirely by the use of water for cooling purposes in steam power plants and large industries. Enormous volumes of water are released, in general, with little contamination or deterioration. Power and cooling demands will, however, increase in proportion to domestic and industrial development of the area.

6. *Navigation and transportation* will become even more extensive with the advent of the St. Lawrence Seaway. The expenditure of many millions of dollars for water development to assure the fullest use of the seaway seems justified.

Each separate phase of the legitimate water uses just presented has a right to assert itself to secure fulfillment of its needs. Competition, bound to develop when satisfaction of needs requires the use of the same or adjacent waters, often results in frictions. Thus, one or more of the legitimate uses may require resolution or adjudication of conflicting interests. Control or allocation may be the answer, but Ohio must develop a form of regional cooperative effort and use far more practical and workable than any devised to date.

After 10 years, Ohio is faced with a developing atomic age, a regional-area population 25 per cent greater, and a doubled tax duplicate. A basic difference in distribution has been caused by by decentralization, the exodus to and the development of "Suburbia." The water works industry is worried at Suburbia's continuing, accelerating growth and about these factors: industrial development, employment, home construction, population, tax duplicate, income. The percentage increase of these items in Suburbia leads the parent areas in northern Ohio. Elmer L. Lindseth, President, Cleveland Electric Illuminating Co., said in May 1955:

This [higher average family income] is a mighty significant fact, that nine in every ten suburban census tracts have a higher average income than the median for all tracts within the central city. It adds a new economic dimension to the quantitative evidence of decentralization we have been examining. It clearly shows who it is that is moving to the suburbs, and who it is that is being left behind in the central city. The prosperous elements are going, and the marginal income families remain. This is by no means surprising, but it is tremendously significant. It points up the fact that quantitative decentralization is accompanied by economic centralization: the concentration of purchasing power, job security, and high taxability in the suburbs; and of low income, marginal employment, and high welfare and relief needs in the central city.

Future Conditions

In northern Ohio in 1965, the author expects that decentralization will have continued, the St. Lawrence Seaway will be a reality, population will have increased another 25 per cent, and the tax duplicate, including Suburbia, will have risen at least another 50 per cent. In addition, all vital facilities and services will have followed and met the trend by careful and courageous utilization of an area of virtually unlimited potential. Ohio will have mastered the art of urban regeneration, suburban expansion, and regional cooperation.

Beyond a reasonable doubt, 10 years from now the state will have succeeded primarily because it arrived at a solution to the conflicting uses and needs of water. Northern Ohio is keenly aware of its water potential. Only water is a regional basic necessity. In 1965 it will no longer be taken for granted that large central cities must finance services for areas beyond their limits because of an unrealistic and illogical bond of necessity. A new type of regional political entity may have been evolved, permitting cooperation without the full loss of local autonomy and responsibility. It will not be easy and each problem will be different. The water industry will be in the vanguard of future developments. The northern Ohio water utilities have already recognized their needs, acknowledged their shortcomings, and agreed to sit down together.

Frankly, the all-important political solution cannot be described because it has not yet been found. It is recognized and pointed out that such a solution is needed. A surprisingly large number of civic leaders have already developed an approach to the problem of working with each other for mutual benefit. The water supply field is proud that it has pioneered new developments in northern Ohio, an area that is a "heartland" location in the midst of the country's greatest markets and resources.

References

1. Plagemann, Bentz. Ohio. *Holiday*, **17**:39:6 (Jun. 1955).
2. *US News and World Report* (Feb. 25, 1955). pp. 70 and 71.

Correction

In the article, "Factors Affecting the Determination of Fluoride in Water With Zirconium-Alizarin," by William L. Lamar and Paul G. Drake (June 1955 Journal, the second sentence of the last paragraph on p. 567 is in error. The paragraph now reads:

> Shown in Table 4, the effect of acidity, increasing the fluoride reading, became observable at and below pH 4.0. At this point, the effect is equivalent to only + 0.02 mg fluoride. . . .

The correct value is + 0.002 mg fluoride. Similarly, in the second column of Table 4 (p. 571), all the fluoride error values are too high by a factor of 10; thus, for example, at a pH of 2.2, the fluoride error is 0.012 mg, *not* "0.12" mg as given. Readers desiring to correct their June copies will find a corrected version of Table 4 in the current issue, on p. 86 P&R.

Water Rights Policies in the Southeast

Clair P. Guess Jr.

A paper presented on Mar. 22, 1955, at the Southeastern Section Meeting, Savannah, Ga., by Clair P. Guess Jr., Executive Secretary, State Soil Conservation Committee, Columbia, S.C.

FAILURE of a supply to meet basic water needs will cause distress in any section of the United States. Every state and most foreign countries have—as part of their general property laws—laws governing the use of water. The states have dealt with rights of water use by recognizing, usually in modified form, the theory of the common law, by initially adopting the doctrine of statutory appropriation, or by initially adopting the common law and later changing over to the appropriation principle.

The western states have all chosen the appropriation doctrine either exclusively, as in the Rocky Mountain States, or in large part, as in the Pacific Coast and Great Plains states. In the Rocky Mountain States, the riparian doctrine was repudiated completely in favor of the doctrine of appropriation, either by law or by constitutional provision. Other states have superimposed such principles on a system recognizing common-law rights in use at the time of the adoption of the appropriation procedure. Some of the Great Plains States have moved steadily to reduce the importance of the riparian doctrine, because it has proved unworkable in meeting development and conservation needs. It has also become necessary for the eastern states to regulate the diversion and use of water. The common law was adopted early by many states, although some, such as New Jersey, New York, and Pennsylvania, impose strict control on the use of ground water in overdeveloped areas.

Recognition of the appropriation doctrine applicable to ground water has taken a somewhat slow and varied course. Several states have appropriation statutes for ground waters. Certain phases of the regulation of ground water are left to local groups, because of the variation from place to place in conditions of supply, use and replenishment.

South Carolina, like many other states, adopted the common law of England long before the American Revolution. After the revolution, this state acquired rights in its defined waters or watercourses which it did not previously have. The riparian law of watercourses was adopted in 1837 in connection with a dispute between two mills on the same stream. Development of this law since that date, however, has been comparatively limited and has been concerned mainly with deciding reasonable use in terms of quantity and quality. Thus, pollution control first arose in court decisions on the riparian law of watercourses. Detention of water for a few hours has been held a reasonable use,

but longer storage or diversion for nonriparian use has been held to be unreasonable.

Until the early 1930's, consumptive use of water was limited largely to domestic and municipal purposes, while nonconsumptive use of streams was for such purposes as navigation, power generation, and wastes disposal.

Need for Increased Supply

There has been a pronounced acceleration in land use and water management programs in recent years, particularly in the piedmont and coastal areas, but the most rapid development took place during and just after World War II, a situation accompanied by greatly increased consumption of water for irrigation, livestock raising, industries, and municipalities. Part of the additional supply has come from ground water sources. Low-cost power on the farm has been an important factor in the use of both surface and ground water for irrigation. Lands that never before produced crops of any kind are now being developed through use or control of ground water to provide forage for livestock.

Recent conflicts among water users have been brought about by these factors:

1. Industrial expansion and development demands increasing quantities of high-quality water.

2. The products of industry, contributing to a higher standard of living, tend to increase the daily per capita requirements.

3. Population increases necessitate greater sources of supply.

4. Population shifts from rural to urban and industrial centers increase the demands for water at the growing localities.

5. Experience and research has led to greater use of water in agriculture.

Riparian Rights

When expanding agricultural, industrial, municipal, and recreational demands for water develop where supplies are limited, the determination of who has a legal right to use the water must generally be sought in a court, whose only guidance in most southeastern states is the riparian rule of law. Essentially this principle of the common law is generally interpreted to mean that an owner of land adjacent to a flowing stream and lying within the immediate watershed of that stream has a right to have the water run past in undiminished quantity and unimpaired quality. Each riparian owner, however, may make reasonable use of the water for his own particular needs, as long as he returns the flow to the watercourse before it leaves his property. Because he is not charged with evaporation or seepage losses or for the impairment in quality if his use is reasonable, the stream may be depleted in quantity or impaired in quality.

Considering the general interpretation of riparian law, water may not be diverted from riparian to nonriparian land without the prior consent of the riparian owners on the stream or the authorization of the state legislature, and the vested rights of the riparian owner must be fully protected. Riparian owners tend to control the surplus water above their needs unless the state provides for its disposition. Riparian rights arise only by ownership of land, not by use of water. Such rights, however, may be

lost by another's gaining a prescriptive right to the same water.

The right-in-common of all the riparian owners along a stream is satisfactory under a simple type of economy in which water use is mainly of the so-called natural, nonconsumptive types, such as livestock raising, domestic employment, fishing, hunting, and navigation. When shortages are created by industrial and agricultural expansion or drought, and when water uses become more consumptive and artificial in nature, however, the riparian right is less suitable in that it is indefinite as to amount, time, and place of use, factors of importance in periods of scarcity.

The risk and insecurity involved in riparian rights, the lack of emphasis upon beneficial use, and the fact that the doctrine does not ordinarily permit diversion to nonriparian lands present problems in an expanding economy. There are large areas in the Southeast which are not riparian to any stream and which need more water. Under the riparian rule, a supposed injury must be created before a court can decide upon the correctness of any use. This system of rights leads to confusion, uncertainty, and insecurity in putting the abundant supplies of the Southeast to their best use.

Legislative Grants

Many states have already exerted the right to control and assign water. Industrial uses—particularly large hydroelectric developments—and municipal improvements have often been granted specific water rights by legislation, including diversion from one stream to another or to nonriparian lands. Although rights gained by this method are secure, it is a cumbersome process. If many consumers were to seek such guarantees, the programs of the state legislatures would be overcrowded, and a good deal of confusion and unwise and overlapping decisions would occur.

Prescriptive Rights

A prescriptive right to water is acquired through use that is adverse to the true owner of the water right. Such use must be open, notorious, and continuous for the statutory period. A prescriptive use cannot ripen into a valid water right if the use is permissive in the first place.

The prescriptive right is for a definite amount of water at a specific time and for a particular place, as in the statutory appropriative right. All of the necessary points must be convincingly proved in court, but, afterwards, the right constitutes one of the best guarantees to continued usage that exist in law. A prescriptive right arises most often in periods of shortages and competitive uses. Because it is for a definite time and specific amount, it may take precedence over the riparian right. A prescriptive right is exclusive, in contrast to the riparian right-in-common. The concept of mutual prescription among ground water users may be involved in prescription. Damage by or to water, as well as the use of water, is involved in the doctrine of prescription, which encourages use of water, and allows improper extraction to form the basis for future rights.

Appropriative Rights

An appropriative right is authorized by statute, but the user must comply with all the requirements of the law. He may not be denied his right as long as vested rights and the public interest

are not adversely affected. The person first appropriating water and putting it to beneficial use within a reasonable period of time acquires a prior right to continued reasonable use. Inasmuch as beneficial use is the essence of appropriative right, appropriation statutes place primary emphasis upon encouraging the sound development, wise use, conservation, and protection of water.

The appropriative right principle is a conservation and beneficial-use policy which provides for the quantitative division of available supplies. As long as there is sufficient water in the stream or other source of supply to satisfy all appropriative rights, it is fully dependable. In times of shortage, however, the earlier valid rights take precedence. Thus, the appropriative right is exclusive and more dependable than the riparian right-in-common.

An appropriative right permits water to be taken from property adjacent to a stream and transported to lands which are not adjacent or which lie beyond the watershed. Such procedures are often essential to industries, municipalities, and farms on high ground away from watercourses. The appropriation laws recognize the relationship that exists between surface and ground waters, whereas the riparian laws usually do not. The appropriation principle seems to suggest a solution to some of the mounting problems in the field of water use and management. Many areas and communities of the United States have come to realize that further industrial or other expansion is limited by water supplies. Investors are beginning to check not only the quality and quantity of water in a locality, but also to the legal rights and protection in the use of such water.

Answers to Problems

During shortages, everyone wonders what was done in the past that was wrong and what can be done in the future to prevent both floods and drought. An answer to the problem seems to lie in balancing supplies against demands. Better watershed protection programs must be organized, along with good systems of impounding rainfall, which must be put to its most beneficial use.

Congress in 1954 passed three acts, which the author believes can help solve local problems with some federal assistance. The Small Watershed and Flood Prevention Act (Public Law 566) is designed to assist communities in developing small watersheds. The federal participation would end primarily with technical assistance and some funds to prevent floods in these areas. Additional storage capacity in impounding structures can be provided for areas willing to assume the extra cost.

The extension of the Soil Conservation and Water Facilities Loan Act allows individual farmers to borrow up to $25,000 for developing water sources. For acceptable groups, this limit is $250,000. These funds may be used in conjunction with Public Law 566. Another aid to the development, conservation, and wise use of water is the Amended Federal Revenue Code of 1954, which allows the cost of improvements for conservation to be counted as an operating expense for tax purposes. The present Congress is considering the Small Reclamation Projects Bill, which will aid limited areas.

Some recognition and help in conservation and development is now being granted to the Southeast, after being limited to the West for nearly 40 years. In addition, there is need for the adoption of a water law that will secure the rights of the borrowers and investors under federal loans.

Requirements for Future

The Southeast is bountifully supplied, on an overall basis, with water, climate, forest, and many other factors essential to economic growth. The distribution and dependability of rainfall and streams, however, vary materially in time and place. Definite rules must be established in the field of water management for future growth. Some form of the appropriative system in water law, combined with portions of the existing common law, will probably offer many new opportunities to the Southeast, if the combined principle is adopted in proper form to meet the needs of individual states. Measures for this purpose should:

1. Protect future investments in the use of water
2. Develop an orderly system for acquiring new rights to water use
3. Protect and uphold all present existing valid rights to the use of water
4. Discourage the wasteful and destructive use of water
5. Encourage a sound system of balancing supplies and demands through carefully planned development
6. Help evaluate locations for industrial development to prevent conflict in water use in the forseeable future
7. Protect municipal supplies with reasonable guarantees for future expansion without need for frequent resort to costly condemnation proceedings
8. Help adjust sectional competition in agricultural production.

Leadership and foresight is necessary in the solving of water problems. Great opportunities lie in working together with soil conservation districts, farmer organizations, chambers of commerce, industrial organizations, and other groups.

State Water Resources Legislation in 1955

Panel Discussion

A panel discussion presented on Jun. 13, 1955, at the Annual Conference, Chicago, Ill.

Introduction—*Stephen W. Bergen*

A paper presented by Stephen W. Bergen, Research Assoc., Conservation Foundation, New York, N.Y.

STATE water legislation is arousing wide interest because of the rapid, unending rise in water use, which reflects a steady population growth, the flight to the suburbs, the increased needs of industry, and the spread of irrigation east of the Mississippi in recent years. Other factors behind such concern are the rise in average personal incomes and the additional amount of leisure time, which enable more and more people to enjoy the recreational values of water.

The mere mention of these trends —economic and social changes which interact with each other—suggests the magnitude and complexity of the job that the states have before them in the field of water control. Obviously, every sector of a state's economy must be taken into account as ways of guiding water development and use are worked out. A report (*1*) prepared in 1953 by New Hampshire states:

It is already apparent that fish and wild life, hydro-power, pollution, flood control, manufacturing, forestry, recreation, water supply, and an endless list of human values revolve around water, not separately, but in a complex of interrelationships. This investigation has revealed the tremendous number of public agencies and the multiplicity of interests that are concerned with the control and use of our water resources. In most cases, public policy is divided among several agencies; in some cases, there is no public policy; and in other cases, the policy of one agency is directly opposed to the policy of another.

On their own level, the states face many of the same knotty questions that concern the federal government.

The western states, especially those in the drier regions, have always been active in developing and preserving water resources. Some states, such as Ohio, North Carolina, and Illinois, in the eastern part of the country have also had relatively intensive water programs for a number of years. The outstanding fact at the present time, however, is that so many states have become water conscious and are now studying water problems. Many states, such as Tennessee and Kentucky, have appointed special commissions to determine resources and needs. The difficult matter of water rights legislation has been receiving particular attention,

notably in the South, as well as in the Midwest. The following regional reports present the history of some of the water rights bills recently introduced in state legislatures. A great deal of the work of these bodies, however, has dealt with other aspects of the water picture, such as the planning and financing of water developments and the establishing of water conservation districts.

Reference

1. State Planning and Development Com. New Hampshire Water: Governmental Responsibilities and Activities in Relation to the Water Resources of New Hampshire. State Council on Resources and Development, Concord, N.H. (Dec. 1953).

North Atlantic States—*Charles H. Capen*

A paper presented by Charles H. Capen, Chief Engr., North Jersey Dist. Water Supply Com., Wanaque, N.J.

Most of the legislative activity in the North Atlantic States has been of a preliminary nature, not yet nearly adequate to cope with the serious problems faced in many of the states involved.

Maine

According to J. Elliott Hale, chairman of the Water Pollution Committee of the Maine Water Utilities Assn. (*1*), this state has already classified the quality of about 10,000 miles of its waterways. An additional 8,000 miles are to be determined by the present legislature, leaving about 12,000 miles unlabeled, a good portion of which will be quite difficult to improve. Hale also lists these resolutions or acts concerning water pollution control:

1. No. 1,092, to study all phases of stream pollution and authorizing $75,000 for the work (about $250,000 will be required)
2. No. 1,204, to add members to the Water Improvement Commission (two additional members to the seven-man board are proposed in order to overcome the alleged influence of two other persons)
3. An unnumbered act, to create an authority for each river basin in the state
4. No. 1,331, to classify municipalities and industries with the aim of having the former set aside money each year to build up a reserve for waste treatment.

Massachusetts and Connecticut

Massachusetts. Governor Herter assigned state commissioners on natural resources, agriculture, public health, commerce, public works, and metropolitan districts to study and report on the purity and quality of Massachusetts water supplies.

Connecticut. Connecticut is apparently concerned with these three items that are to be studied after the establishment of a Water Resources Commission:

1. A sharp increase in the use of irrigation waters by Connecticut agriculture
2. Competition between cities for water supplies
3. Removal of ground water at an alarming rate through gravel-packed wells.

Delaware and Pennsylvania

Delaware. On Apr. 1, 1955, the Delaware Water Resources Study Committee submitted a very comprehensive report on the water supplies of the state (*3*). This, one of the most complete documents on the statewide study that has been produced, should serve as a very potent guide for future water developments in the state.

Pennsylvania. The Pennsylvania legislature introduced a bill that would authorize a municipality to operate, control, sell, and lease facilities for the production, transmission, and furnishing of gas, electricity, steam, water, or sewage within or without municipal limits. Perhaps the most significant proposed act was one that would authorize joining New Jersey in permitting the construction (within 50 years) of a dam at Wallpack Bend on the Delaware River to provide a water supply for both states. As of May 1955, the bill had passed the Assembly, but not the Senate. When such action was not completed by Jul. 1, 1955, the compact between the two states regarding the dam automatically expired.

New York and Maryland

New York. The New York City Board of Estimate approved an appropriation of $85,350,000 to start the construction of the Cannonsville dam and reservoir on the west branch of the Delaware River. The ultimate cost is estimated at $140,000,000.

Maryland. A bill introduced in the Maryland legislature early in 1955 would permit Baltimore to issue $45,000,000 in water bonds for tapping the Susquehanna River. This work is now going ahead, and it may be assumed that construction permission has been granted by the legislature.

New Jersey

In New Jersey many water bills were introduced in the 1955 legislature because of the proposal by the North Jersey Dist. Water Supply Commission to carry out the Round Valley Project on behalf of several communities. Application for diversion rights has been made to the State Water Policy and Supply Council, and the first hearing on this manner has already been held.

Most people in northern New Jersey want the project, but a small block of senators from rural counties object. Bills submitted to the legislature range all the way from proposing a $300,000 appropriation to buy the site (although this is only a fraction of the cost of the land), to a motion for holding a referendum to authorize spending $85,000,000. Engineers have been engaged at a cost of $164,000 to make a further report, which some persons regard as unnecessary.

At the end of May, a new bill was introduced to extend the date (from Jul. 1 to Dec. 31) by which time Pennsylvania must approve the agreement permitting construction of a dam at Wallpack Bend. This action has been viewed in some quarters as an attempt to block the Round Valley Project.

South Jersey has been promised a supply from the state-owned Wharton Tract. Some of the contemplated legislation calls for starting work immediately on this undertaking. Another bill provides for licensing those engaged in artificial weather control (rainmaking).

To date, none of the bills discussed here has passed. Shortages of water in various parts of the state continue to plague the citizens.

Other States

No details about water legislation have been received from New Hampshire, Vermont, or Rhode Island.

Most of the North Atlantic States have serious water problems, a fact shown by proposed legislation. More action and less discussion is needed in the future.

References

1. J. E. HALE. Stream Improvement! What Next? *J. Me. Wtr. Utils. Assn.*, **31**:3:19 (May 1955).

Southeastern States—*G. S. Rawlins*

A paper presented by G. S. Rawlins, Vice-Pres., J. N. Pease & Co., Charlotte, N.C.

The South Atlantic States generally follow both the law of riparian rights, as interpreted by the courts in a variety of cases, and the law of statutory rights for certain users of water. Irrigation in these states is now of small consequence, but will probably be enormous in the future. In North Carolina, the area irrigated in 1944 was approximately 400 acres, but by 1954 this amount had risen to 17,850 acres. Tests have shown that the use of irrigation increases the yield of tobacco about 300 lb per acre with an additional value of approximately $280. When the farmers become fully aware of such possibilities, the agricultural demand for water will be a very serious problem.

Virginia

Analysis of available material shows that Virginia has been active in the field of water resources legislation in recent years. In 1953, Governor Battle directed the Virginia Advisory Legislative Council to study and report on the problem to the Governor and the General Assembly (*1*). The council was to provide appropriate suggestions for the establishment of a state comprehensive water code, designed to facilitate present and future economic development along sound and constructive lines.

The final recommendations specifically covered: definition of terms for clarity, creation of a water conservation board, and establishment of a set of administrative and judicial procedures. A bill introduced in the 1954 Assembly directed that the Virginia Advisory Legislative Council act accordingly and report to the 1956 Assembly.

North Carolina

North Carolina was made painfully aware of the problem of water resources by the severe drought of 1954, as well as by earlier experiences. In fall 1953, Governor Umstead appointed the Water Resources Advisory Committee to consider the problem. This group later drafted legislation which was introduced in the 1955 General Assembly (*2, 3*). These bills state:

> The general welfare requires that the water resources of the state be put to beneficial use to the fullest extent of which they are capable, and that waste or unreasonable use, or unreasonable

method of use, of water be prevented, and that the conservation of such water be exercised with the view to the reasonable and beneficial use thereof in the public interest.

. . . Natural bodies of water are public wealth of the state and subject to appropriation in accordance with the provisions of the proposed act, provided, however, that the act shall not deprive any person of any vested right in the use of water.

These are the precedences that future appropriations of water for different purposes will take: [1] water for human consumption; [2] water for agriculture and industrial production; and [3] water for other beneficial uses.

This legislation was not passed by the 1955 General Assembly. There are many obvious difficulties to be resolved in changing from common law to the completely different approach of appropriation.

A law (*4*) was enacted (H.B. 962) which will enable the governor—in a water emergency in a specific area—to appropriate water within that locality and to regulate its use. This legislation provides for a Board of Water Commissioners, whose assigned duties are as follows:

1. To carry out a program of planning, research, and education concerning the long-range use of water resources
2. To maintain a general inventory of water resources
3. To notify municipalities or other governmental units of potential water shortages or emergencies, with recommendations
4. To file with the governor and General Assembly a biennial report of the activities with recommendations for improving, conserving, and using water resources
5. To make available to the public information on all legislation recommended by the board.

South Carolina

A competent authority has stated that South Carolina has been more active than any of the other South Atlantic States. The proposed North Carolina legislation is identical in its statement of policy with the policy of South Carolina.

A study of water policy was initiated by the 1953 General Assembly, when the Senate, the House, and the Governor, appointed a joint committee, which did a fine job of assembling and weighing the facts. It recommended a new water policy for South Carolina and suggested to the 1954 Assembly legislation that would guarantee existing vested rights to surface water that is being used for beneficial purposes. This bill provided for an orderly, legal way in which additional uses could develop. An antiquated doctrine would have yielded to one based on a realistic approach to present and future water use, but the act was not passed. An amended bill was introduced in the 1955 Assembly. Further effort was apparently made to clarify the meaning and extent of "vested right." According to recent reports, this legislation is tied up in the Senate Agricultural Committee with no chance of being released during the present session.

C. P. Guess Jr. discusses the philosophy and the problems of the proposed new water policy in a paper on p. 840 in this issue.

Georgia and Florida

There is nothing significant to report for Georgia. The State Water Law Revision Commission—whose purpose it is to study and recommend

changes in water laws—has no current actions now pending.

According to Frank E. Maloney, the present status of water laws is extremely uncertain (*5*). Older case law adopts the English common law of riparian rights on surface streams and allows complete freedom of withdrawal to owners of land overlying ground water supplies. More recent case law seems to modify these rules by engrafting the principle of reasonable use as a limitation on the landowner's absolute rights.

Although the situation is not yet generally critical, the legislature is expected to appoint a study commission to report in 1957.

Alabama and Mississippi

There has been considerable legislative activity in Alabama. Information is not available for Mississippi, West Virginia, or Louisiana.

References

1. Senate Document No. 17. State Senate, Richmond, Va. (1953).
2. Senate Bill No. 153. State General Assembly, Raleigh, N.C. (1955).
3. House Bill No. 298. State General Assembly, Raleigh, N.C. (1955).
4. House Bill No. 962. State General Assembly, Raleigh, N.C. (1955).
5. MALONEY, F. E. Laws of Florida Governing Water Use. *Jour. AWWA*, **47**:440 (May 1955).

Ohio Valley States—*C. H. Bechert*

A paper presented by C. H. Bechert, Director, Div. of Water Resources, State Dept. of Conservation, Indianapolis, Ind.

Most of the midwestern states have suffered droughts or severe water shortages during the past 2 years. That fact, coupled with the increasing interest of farmers in irrigation, has caused many administrators and other persons engaged in water resources investigations and water development projects to review seriously existing water rights and give thought to future state water policies.

Indiana

The number of acres of land under irrigation in Indiana increased approximately 75 per cent each year during the last 2 years. There was some agitation for immediate control of the use of water for such purposes. Persons closely associated with the water problems involved felt it unwise to enact laws attempting such regulation until a thorough study had been made of the matter. The State Legislature at its last session followed the latter train of thought and passed the Indiana Water Resources Law, the most important water legislation of 1955. Under this law, water in any natural stream, lake, or other body of water which may be applied to any useful and beneficial purpose is declared to be a natural resource and "public water" of Indiana. Such water is subject to control and regulation for the public welfare as determined by the General Assembly. Although ground waters were not included in this policy declaration, the act states that the study committee is to conduct a comprehensive survey of water rights and water management laws for both surface and

ground waters. A report will be made in 1957.

A bill introduced in the Indiana legislature provided that all water well drillers had to register with the state and must submit well logs to the conservation department. Another proposed law required that a permit had to be obtained from this department before a well could be drilled. Both of these bills, however, failed to pass.

The legislature ratified the Great Lakes Basin Compact, part of the purpose of which is to promote the orderly, integrated, and comprehensive development, use, and conservation of the water resources of the Great Lakes Basin. The states eligible to join this agreement are Indiana, Michigan, Wisconsin, Illinois, Minnesota, New York, Ohio, and Pennsylvania, as well as Ontario and Quebec, Canada. At present, besides Indiana, only Michigan and Minnesota have ratified this compact.

The topographic mapping program of Indiana will be materially speeded up after Jul. 1, 1955, inasmuch as the legislature increased the biennial appropriation for mapping from $100,000 to $400,000. This program will be completed in 10 years.

Kentucky

In 1954 Kentucky passed a water resources law very similar to the one enacted by Indiana, declaring that the water of any natural stream or lake is a natural resource and "public water" and is subject to control and regulation for the public welfare. The Kentucky Legislative Bureau, directed to conduct a study of water usage and rights, will report its findings to the 1956 General Assembly.

Ohio

The Governor of Ohio in May 1954 appointed a committee of 100 persons to advise him about the state's water resources problem. One of the first accomplishments of this group was to get the Ohio Legislative Service Commission to review the state water rights laws (*1*). The committee also persuaded the legislature to authorize the Dept. of Natural Resources to collect, study, and interpret all available information, statistics, and data pertaining to the supply, use, conservation, and replenishment of the underground and surface waters in the state. Because this inventory is to be taken on a basin-by-basin basis, the state has been divided into 108 such areas of about 400 sq miles each. The sum of $170,000 was appropriated for this project. About 4–6 years will be needed before a comprehensive water code or plan can be prepared. Legislation is pending in Ohio for the establishment of a program to remap the state topographically on a $7\frac{1}{2}$-min quadrangle basis.

Michigan and Illinois

A resolution introduced in the 1955 Michigan legislature provides for a special committee of the legislature to continue the study of the codification of the drainage laws and problems of water resources in the state. The erosion problems arising from high water levels of the Great Lakes will also receive attention in the report which is to be made in 1956. A rather comprehensive water well control bill to establish rules and regulations concerning well construction was recently defeated. The proposed act would have provided for conservation and

appraisal of the ground water resources of the state.

The Illinois legislature has before it a bill, with an appropriation of $250,000, to create a commission to study the water and drought situation in the central part of the state. This group, composed of five members of the Senate and five members of the House of Representatives, would be empowered to make a thorough study of conditions to determine methods of providing water for drinking and commercial uses in central Illinois. Other proposed legislation would create a new agency to handle water supply, flood control, water transportation, and sewage disposal problems in the Chicago metropolitan area. The sum of $50,000,000 has been recommended as state aid to the proposed project, with the remainder to be financed through revenue bonds.

Wisconsin

Although no legislation has been introduced in the Wisconsin legislature concerning study or adoption of a code on water rights, representatives of the Natural Resources Committee, the College of Agriculture, the Public Service Commission, and other interested parties have held a meeting to discuss the subject of water law. It is probable that the matter will be thoroughly investigated by this group prior to the convening of the 1957 legislature. A bill now pending in the legislature to promote the conservation of underground water supplies provides that the approval of the State Board of Health must be secured before a new or additional well may be constructed for any purpose where the rate of withdrawal will exceed 70 gpm. Other proposed laws call for the development of a program of watershed management and the empowering of certain state government subdivisions to raise and appropriate funds for use in developing or creating watershed protection areas or projects.

Tennessee

A bill now before the Tennessee legislature would create a commission of nine members to conduct a study of state water laws, water resources, and water uses, as well as desirable and necessary changes to meet the future water needs of the state. This group is to report its results and recommendations to the governor by September 1956.

Reference

1. Research Report No. 1. Ohio Legislative Service Com., Columbus, Ohio (1955).

Missouri Valley States—*T. W. Thorpe*

A paper presented by T. W. Thorpe, Pres., Thorpe Well Co., Des Moines, Iowa

There has been a considerable amount of legislative activity in the Missouri Valley States. This area of the country has particular interest in conversation and flood control.

Missouri, Iowa, and Kansas

Missouri. Governor Donley in his message to the legislature recommended the creation of a Water Resources Commission. The House of

Representatives passed a bill creating watershed conservancy districts to handle water resources development at a local level, but the upper chamber did not approve. A Senate committee of five members was created to make a study of state water resources problems, water use, and water rights. This group is to report on the need for legislation on watersheds and pollution control.

Iowa. Several water control bills were introduced in both houses of the legislature, indicating a lot of interest and some confusion. Because more information than available was needed before a policy could be established, the legislature jointly resolved to create a special committee to study state underground and surface waters in relation to water rights, irrigation, and drainage. This group will make a report, including drafts of proposed bills, to the governor by Nov. 15, 1956.

Kansas. Kansas enacted the Watershed District Act in 1953 and adopted a number of amendments two years later. The duties of the newly created State Water Resources Board are to collect and compile information pertaining to climate, water, and soil, as related to agricultural, industrial, and municipal purposes. This organization will also determine the availability of water supplies in the watersheds.

Nebraska and North Dakota

Nebraska. Nebraska is concerned about the increased use of ground water for domestic, agricultural, industrial, and other uses. The Legislative Council appointed a committee of seven to make a comprehensive and detailed study of ground and surface water. The final report is to include the results of the study, recommendations, and proposals for necessary legislation, if any.

North Dakota. Steps were taken by the North Dakota legislature to maintain drainage systems and to protect the rights of underground water users through consolidation of water controls. The State Water Commission is empowered to issue water rights permits for municipal, industrial, and irrigation uses. Domestic and municipal needs continue to have the highest priority, apparently because of the increasing demand for irrigation water. North Dakota also enacted a law establishing a 22-county conservancy district to utilize diversion water from the Garrison Dam.

South Dakota and Minnesota

South Dakota. South Dakota is very water conscious, having recently passed two bills revising the old water code. A Water Resources Commission consisting of seven members was created to control all water resources.

General domestic use—including all ordinary application around the home and farm, as well as irrigation of not more than ½ acre—has priority over other consumption. Municipal use, seemingly second in importance, does not include the irrigation of crops on a commercial scale within city limits or extensive recreational employment.

The legislation endeavors to control the vested rights of landowners in continuing the use of waters. These bills are of far-reaching importance, and South Dakota's control system could profitably be studied by other states.

Minnesota. After a 2-year study, the Minnesota legislature passed a bill covering the conservation of the natural resources of the state through better land utilization, flood control, and controlled watershed districts.

Cities and towns do not have to obtain a permit to develop a water supply in municipal limits, but one must be secured for projects undertaken outside the incorporated area. Recently amended laws to conserve ground water and to prevent waste are administered by the three-man State Water Board.

Montana and Wyoming

Montana. Montana, conscious of the need for water control legislation, has endeavored to pass a comprehensive water resources program. Interested groups, such as the state and municipal health and welfare agencies, farmers, wildlife conservationists, and sportsmen came together and worked out a bill which is acceptable to all.

Legislation was enacted to prevent dumping sawdust and lumber mill waste into streams. A stream pollution bill also passed, but a law to establish priority rights in the use of ground water was not approved. The Columbia River Pact also was rejected.

Wyoming. Wyoming is still bound by laws made in 1947. A bill introduced in the 1955 legislature to provide more control of ground water development failed to pass. Some minor changes, however, were made in sections of less important irrigation laws. This state is working in the direction of a policy of careful water control.

Southwest States—*M. B. Cunningham*

A paper presented by M. B. Cunningham, Supt. & Engr., Water Dept., Oklahoma City, Okla.

In many southwestern states, laws of water rights have long been well established. Current legislation indicates there will always be a need to review past experiences in order to derive new ways of meeting the increased demand for water. For example, some laws will have to be changed in order to finance or construct expensive distribution systems to avoid disastrous shortages.

Oklahoma

After abandoning hopes that the 1955 Oklahoma legislature would create a new statewide water authority empowered to issue self-liquidating revenue bonds to finance new supplies, Governor Gary urged the lawmakers to set up a study committee to work out a plan for water development legislation in 2 years.

A new law provides for a change in the state constitution if the voters will approve. If they do, cities and towns will be able to join together in establishing water supplies and distribution systems. Municipalities will also be able to make contracts for a period of 25 years, or less, to purchase water, which would be paid for from revenue. At present, contracts affecting revenue are limited to the current fiscal year.

A bill designed to permit incorporated areas to finance needed water facilities from revenue was not approved by the legislature. Water utilities in Oklahoma must be operated and maintained from revenue, because cities obtain practically no funds from ad valorem taxes. Capital investments, however, are generally financed from general obligation bonds.

Colorado

In discussing Colorado's water problems in a message to the state legislature, Governor Johnson said:

The unfortunate controversy between the eastern and western slopes must be resolved constructively. Colorado should see a solution which would benefit both slopes and injure neither. It can be done. It must be done. Colorado's ground water resources need to be explored to the fullest extent by competent technicians, and these precious resources need to be protected by law with respect to private and public equities and against abuse and waste. The Colorado Water Conservation Board must get on top of this problem with firm and aggressive determination at once, and give the General Assembly its views as to whatever legislation is required to protect the public interest. An extensive and cooperative groundwater exploration with the US Geological Survey should proceed unhampered by lack of necessary state funds.

Arkansas

A bill was passed by the Arkansas legislature in 1935 providing for the creation of a special eleven-man committee to study surface water rights legislation. This new law also grants powers of eminent domain to water works, but municipal governments may fix the rates. The water utilities are also authorized to transfer any surplus from operating and maintenance funds to bond redemption accounts, and cities are empowered to borrow (without having the indebtedness count in the constitutional limit), on promissory notes, for the preliminary expenses of expanding existing systems.

Texas

A series of water conservation proposals drafted by an interim study committee and backed by Governor Shivers were introduced in the Texas legislature. A proposed state constitutional amendment authorizing a $100,000,000 bond issue for state aid of up to 33 per cent or $3,000,000 to local water conservation projects was passed by the Texas Senate and sent to the House. Under this plan, which would be referred to the electorate on Sep. 20, a state property tax of 3 cents on each $100 of assessed value could be levied to finance the program.

Other legislative developments included the enactment of two laws aimed at aiding water conservation. One requires water districts to register their boundaries with the State Board of Water Engineers, and the other requires this board to conduct hearings before granting approval of water projects involving federal aid.

New Mexico

Governor Simms of New Mexico recommended, as follows, that favorable legislative consideration be given to a bill:

. . . which will have as its purpose the anticipating of revenues and the placing of monies received by the Water Reservoir Income Fund in a new revolving fund which would be created.

This revolving fund would be used to provide money needed by the state and its subdivisions to participate in a program of development and improvement of small reclamation projects with federal assistance under authority of legislation now pending in Congress. . . . I also urge that the surveys of underground and surface water already in progress, should be speeded up, and to this end you should be prepared to appropriate the necessary money.

Utah

Information was not available for Utah.

Pacific Coast States—*L. J. Alexander*

A paper presented by L. J. Alexander, Chief Engr., Southern California Water Co., Los Angeles, Calif.

In the Far West, water has been of more legislative concern for a longer time than anywhere else in the country.

Nevada

Four important bills were passed by the Nevada legislature. One of these provided for the conservation and distribution of ground water in each water district. This bill and an amendment to an existing law permitted the state engineer to investigate a ground water basin that he felt was not being replenished naturally and to start a program of curtailment. He was also given the power to designate priority of use. In some parts of Nevada the highest priority is given to cattle grazing rather than to domestic or irrigation uses.

Another bill provided for the development of cloud-seeding programs. A third bill, parallel to one in the California legislature, initiated a study of the waters of Lake Tahoe and the Truckee, Carson, and Walker rivers, which are interstate streams. The last bill created water conservancy districts, whose directors are to be appointed by a court rather than to be elected by public elections. Formation of such areas could be initiated by property owners whose total assessed valuations were more than $50,000, an amount at least 10 per cent of the required assessed value for the entire locality.

Washington

A number of water bills were presented to the Washington legislature, but they were not passed. The governor, however, appointed a Water Resources Committee, which has proposed a water policy for the state.

Oregon

A recently enacted law has established a Water Resources Board, which replaces five or six other bodies whose functions overlapped. This organization has been directed to prepare as rapidly as possible an integrated and coordinated water policy, to which all other public agencies will be required to conform, specifically including those of the federal government. The Ground Water Act of 1955, which declares that all Oregon waters belong to the state, was primarily designed for control of the ground water basins. The state engineer is empowered to maintain reasonable levels in all the ground water basins, and he is permitted to make the final determinations of extraction rights.

California

In California, more than 600 bills presented to the 1955 legislature had to do with water. Many of these were introduced by various senators just to attract attention to themselves. Probably the most important proposed legislation was the so-called Feather River Project, in which water would be taken from the areas of surplus water in the northern part of the state and delivered to the southern part over a distance of about 500 miles. This procedure has been balked by the fact that the counties of origin insist on guarantees that permitting water to be transported for use elsewhere will not preclude later

appropriations of water for local development. The southern section feels that the northern area should be guaranteed sufficient supply for reasonable development in the future. In return, the northern part of California is quite willing to furnish surplus water rather than waste it to the ocean. Bills to permit this scheme have not yet been passed.

The lower house appropriated funds to purchase the sites for the St. Louis and Orvalles reservoirs, which are necessary to the Feather River Project. This bill, however, was rejected by the upper house. An important law that was enacted to help save the resources of ground water basins permits a pumper to take water from a source nontributary to the basin without losing his rights to ground water.

A recent law requires a person in the southern counties of the state extracting water from an overdrawn basin to reveal his pumpage to state authorities. Upon verification, such recordation then becomes prima facie evidence in any future adjudication. Another law provides for the formation of replenishment districts (see the paper by Krieger on p. 909 of this issue). This is the most far-reaching water legislation in the state's history. A bill proposed by fishermen was passed requiring water works to permit commercial fishers to utilize reservoirs. This law, distasteful, of course, to the ultilities, was vetoed by the governor.

Acknowledgment

Information was provided for Nevada by Hugh Shamberger, state engineer; for Washington by Supervisor Walker of the State Dept. of Conservation and Development; for Oregon by John Barron, manager of the Salem, Ore., Dept. of Water. No information was available for Idaho.

Use and Conservation of Water Resources in Eastern States

Richard D. Hoak

A paper presented on May 4, 1955, at the Pennsylvania Section Meeting, Pittsburgh, Pa., by Richard D. Hoak, Sr. Fellow, Mellon Inst., Pittsburgh, Pa.

THE humid eastern states, which have long enjoyed an abundance of water, are becoming uncomfortably aware of the need for conserving this important natural resource. About 75 per cent of recent municipal water shortages has been due to inadequacy of supply, storage, and distribution facilities. Such situations have often resulted from lack of foresight in planning for future demands on water supply systems, but the time is approaching when dependable local supplies of fresh water will no longer support further municipal and industrial growth in some areas. Whenever such an event can be foreseen, even if remotely, water conservation practices should be adopted at once. Where demands are allowed to exceed supplies, it may be difficult or impossible to institute corrective measures.

It has been predicted that consumption of water for all purposes will be over twice as great in 1975 as it was in 1950, a fact that should be construed as a warning to water works management in districts experiencing rapid urban and industrial expansion. The experience of Houston may be cited as an example of the demand for water outstripping projected needs. A 1943 survey forecast a requirement of 268 mgd by 1970 for the city, but recent estimates have raised this figure to 700 mgd (*1*).

W. W. Horner, chairman of the National Water Policy Panel, has listed (*2*) these reasons for water shortages:

1. Failure to provide for equalization of surface water runoff
2. Overconcentrations of population and industry
3. Ground water withdrawal in excess of natural recharge
4. Water wastage
5. Failure to use available salt water in place of fresh water
6. Selection of plant sites without adequate evaluation of available water for existing or predictable future requirements
7. Inadequate design of water-consuming process equipment.

The above factors relate largely to unsound planning, but many industrial establishments are located where circumstances beyond control or foresight have caused difficult water supply problems. In such instances, maximum use of available supplies is mandatory.

Long-term prediction of the demand for water is extremely uncertain. There is evidence, however, that water consumption is a function of the index

of business activity, and this relationship can be used to estimate short-term requirements (*3*). In the Los Angeles area, for example, an increase of three points in the local index of business activity results in a 1 gpcd rise in water consumption. If this index, a population growth curve, and prospects for industrial expansion were tied together, it should be possible to arrive at a rough estimate of the rate of increase in demand.

Water Conservation Value

Water conservation is equivalent to an increase in the normal supply. The very abundance of water in the East has made it difficult to recognize obvious conservation measures. In the United States, water has been wasted with a clear conscience because there has always been a plentiful amount. A good deal of water is unconsciously wasted by workmen who use far more than necessary, or who fail to shut off valves after the work is finished. Industrial inefficient use of water is readily corrected. One company reduced intake 70 per cent by installation of thermostatically controlled valves to retain cooling water until it reached 80–120°F instead of allowing it to stream through. Automatic controls have been notably successful in conserving water in all kinds of operations.

Comprehensive surveys of water usage in industrial plants have invariably paid for their cost, often many times over, and such undertakings, together with a continuous educational program for workmen, can save enormous quantities now thoughtlessly wasted. H. E. Hudson has cited actual instances of remarkable reductions of intake water through conservation measures (*4*). Compared with maximum intake, he found decreases of 99.7 per cent for steam power generation, 97.3 per cent for petroleum refining, 97.8 per cent for steel making, 79 per cent for soap and edible-oil manufacture, 98.2 per cent for carbon black production, 58 per cent for processing natural rubber, 95.7 for butadiene synthesis, and 82.3 per cent for glass container fabrication. Most of these savings come from recirculation of cooling water. Reductions of this magnitude may not often be possible, especially in an older plant, but they show what can be attained in future installations.

Multiple and countercurrent use of water in the chemical process industry can accomplish large savings. Cooling water can often be reused, and such savings will be multiplied if the same water is used successively in processes where water of poorer and poorer quality is satisfactory. Conservation of water through reuse has certain drawbacks, however. For example, mineral salts and organic compounds tend to concentrate, biological growths may become troublesome, and corrosion may cause difficulty. These factors can be controlled by appropriate water-conditioning installations. Lack of intermediate conditioning in extensively recirculated water is likely to increase difficulty of treatment before the waste can be discarded.

Discharge Water

Spent water forms part of all streams serving industrial areas, and, in some instances, the entire flow is used several times by successive plants. Thus, there has been an unconscious reuse of water for a long time, and the reported intake of industrial water is much

larger than the net withdrawal, a fact also true of municipal water use. As the demand for water increases, however, repeated reuse will cause deterioration of quality unless the discarded water is adequately treated before discharge.

The many uses of rivers and lakes are vital to modern civilization, but their relative importance depends upon the best interests of all the people in particular regions. Surface water has so many natural functions that it cannot adequately provide all of them for everyone everywhere. It would seem to be possible to survey an area and decide upon a priority of water uses which will best serve local needs. Such a procedure is impractical, however, because the conflict of economic and sociological factors that introduce an emotional element which cannot be reasoned away. It is agreed that the highest use of water is to provide a potable supply for domestic needs, but it is often impossible to reach an amicable determination of the relative value of other applications. Across the nation there are many disputes about water and the policy that should govern its employment, but in the East the predominant problem concerns the extent to which surface water should be used to assimilate domestic and industrial wastes.

Pollution Determination

The utilization of streams for ultimate disposal of spent water is essential, inasmuch as this practice permits downstream reuse of waste water. Problems arise, however, in determining how much assimilative work a particular body of surface water should be called upon to perform. Natural streams have a high capacity for converting wastes into innocuous substances as long as overloading is avoided. What constitutes such excess largely depends upon the downstream interests that are to be served. There are many reasons (technical, economic, and esthetic) why it is difficult to fix proper loadings. The principal difficulty in pollution control is the meagerness of scientific data upon which to base limitations of the discharge of various wastes. It is impossible to write a general definition of pollution that will satisfy everyone. What may be called pollution in one situation would not be considered pollution under different conditions. Thus, definitions of pollution derive from priorities of stream uses, and these depend on stream location. Indeed, rigid definitions of pollution should be avoided, especially in legislation, because they prevent the flexibility in appraisal of the effects of pollution that is essential for control in the broad public interest. Handy as precise descriptions are from an administrative point of view, they tend to stifle thoughtful evaluation of the effects of waste water. Several years ago (*5*), it was stated: "Pollution is the discharge of material that unreasonably impairs the quality of water for maximum beneficial use in the overall public interest." Adoption of such a definition would require a valid determination of the public interest and the means by which it could be served, rather than the effortless employment of a set formula.

Pollution Control

In view of the limited knowledge of the specific effects of pollutants on stream biota, it is difficult to establish equitable quality criteria even for rela-

tively simple cases. It is, therefore, manifestly impossible to control pollution fairly over a large area by imposition of strict regulations. It is a generally accepted principle that the assimilative capacity of streams should be fully used to the extent that other beneficial uses will be conserved. A great deal of fundamental research will be necessary before a sound basis can be established for optimum use of the self-purification capabilities of streams. In the meantime, the clamor for pollution abatement will continue to increase. Enlightened agencies are aware of the economic and sociological importance of basing their decisions on dependable data, but pressure from groups which have little understanding of the complex nature of pollution control often force the taking of measures known to be untenable. There is no doubt that the discharge of waste water will become more stringently regulated in the future. Industry should, therefore, cooperate with local agencies by frankly discussing problems and plans and should also undertake constructive laboratory research to provide essential data on waste products. Regulatory bodies are ordinarily unable to conduct long-range research and must depend upon private enterprise for basic information. Thus, in the long run, collaborating in adoption of pollution control measures will benefit industry because it will protect its own interests and perform a valuable public service at the same time.

There are many ways by which a plant can reduce its contribution to stream pollution without waste treatment. Good housekeeping, often a major factor in saving valuable materials and in reducing pollution, is such an obvious measure that it frequently escapes attention. The impressive savings that some companies have been able to effect by taking serious notice of wasteful practices show clearly how much can be accomplished by educating workmen in proper management. A comprehensive survey of water usage, an important first step for in-plant pollution control, will sometimes disclose a degree of wastefulness that will be shocking and will almost always show how to reduce intake. More importantly, such appraisal can point the way to process changes that will improve specific operations and reduce waste.

Conservation Measures

Measures for augmenting local supplies by conservation through efficient use and reuse can be developed by study of water-consuming operations. Because such procedure may not be enough in some plants, attention must be given to replenishment of supplies by natural means or artificial expedients. Of a number of such possibilities, some are practical and already in use, while others are, as yet, only potentialities for the future. One fairly obvious method is to build dams to conserve excess runoff from rainfall. This common undertaking is often impractical, however.

Increasing demands have resulted in greater use of ground water, which is usually preferred to surface water because of greater clarity and uniform temperature and composition. On the other hand, a subsurface supply may have a higher concentration of dissolved solids, hold considerable carbon dioxide in solution, and precipitate some of its constituents, notably iron and manganese. Withdrawals, however, have greatly exceeded the rate

of natural recharge in many locations. Contrary to popular belief, ground water levels are not declining over the country as a whole, even though excessive withdrawals have caused serious difficulty in some areas. Aquifers can be recharged in several ways. For example, if water is used for air conditioning, it can be pumped back into the ground, a procedure required by regulations in some instances, even though a gradual rise in water temperature may result. Sometimes this operation is necessary to prevent salt water intrusion in coastal areas. Percolation ponds have been successfully used to increase the rate of natural recharge in many places.

The use of effluents from sewage treatment plants to recharge aquifers is relatively new. Studies have shown that the mineral constitution of ground water has shown no appreciable change where such replenishment has been practiced. Although much more research it still needed to establish dependable percolation rates and the capacity of soil to handle a given pollution load, it will probably be feasible to use treated sewage to increase ground water supplies. Community acceptance of this expedient would be enhanced if water works and sewage plants were integrated in water production–reclamation operations.

Sea Water Demineralization

The ocean has long been regarded as an inviting source of fresh water. Unfortunately, no one has yet developed an inexpensive process to separate the water from the salt. The US Dept. of the Interior has been making an intensive study of potentially practical methods since 1952. It was wisely decided to use the limited funds appropriated for research upon a number of novel schemes, rather than to sponsor one or two elaborate pilot studies of fairly conventional methods. As a result of this undertaking, several intriguing possibilities have come to light, emphasizing the importance of originality in seeking improved ways to desalt sea water. Some of these new processes will require, of course, much careful investigation before they can be finally evaluated.

Fresh water is being recovered from the ocean at a number of localities where the high cost is not prohibitive. Multiple-effect evaporation can produce salt-free water at $1.50–$3.00 per 1,000 gal, depending on the cost of fuel. This is a high price compared with the 20 cents per 1,000 gal paid by the average householder, or with the 1 cent paid, on the average, for irrigation water. Thus, it became essential to develop relatively low-cost methods to make desalting economically feasible.

Current research on means for increasing the efficiency of vapor-compression distillation indicates that it may become possible to produce fresh water at a cost somewhere in the range of 20 to 60 cents per 1,000 gal. This recovery method differs from conventional distillation in that the vapor from the boiling liquid—after compression to raise the temperature a few degrees—is returned to the heating coil in the still where it condenses and flows out. The efficiency of this type of installation results from higher heat transfer coefficients and better overall heat economy than in conventional stills. At present, it appears that vapor-compression distillation can provide the most practical means for ocean water conversion.

Ion-transfer-electrolysis, another method for producing fresh water from salt water, is based upon electrolysis of saline water in a multicompartmented cell comprised of a series of ion-exchange membranes alternately impermeable to anions and cations. In practice, such a cell will separate the saline water into two fractions—one relatively pure and one containing more dissolved solids than the original sea water. A major economic factor in this process is the initial concentration of the dissolved salts: the higher the concentration, the greater the cost. On the basis of extensive study, it has been concluded that ion-selective-membrane desalting offers the best possibility for economical purification of brackish waters containing about 4,000 ppm dissolved solids (sea water averages 35,000 ppm). Laboratory experience has indicated 94 per cent purification of a 3,600-ppm feed at a total power consumption of 16 kwhr per 1,000 gal, which is equivalent to a net cost of about 20 cents per 1,000 gal.

Other desalting methods include solar evaporation, freezing to separate pure ice crystals, osmotic processes, ion-selective demineralization, and phase separation above the critical temperature and pressure of water. These procedures, involving difficult economic and technical problems, are being investigated to determine their ultimate feasibility.

Induced Rainfall

Replenishment of water supplies by inducing rainfall is another development which holds promise for the future. When rain occurs naturally, only about 5 per cent of the water in clouds actually precipitates. If the fallout could be raised to 10 per cent of the cloud content, the natural supply would be doubled. Such increase is attempted by providing nuclei to promote condensation of water vapor. Dry ice pellets and silver iodide crystals have been used successfully to bring about this effect. There are wide differences of opinion, however, among meteorologists and other experts in the field over the results. Although much research will be necessary before efforts to increase rainfall can be satisfactorily evaluated, there is reason to believe that the technical problems will be solved eventually and that water supplies can be augmented by artificially increasing atmospheric precipitation.

River Associations

In view of the kind of water supply problems that will arise frequently in the future, consideration should be given to establishment of water districts patterned after the river associations which have operated so successfully in Germany. This method of administering water supply and pollution control has been proposed a number of times in the United States, but has made little progress. Cleary (*6*) has recently detailed the operation of such organizations. In general, each is composed of a locally elected board of deputies, which appoints a managing committee and has a commission of appeal consisting of three members named by the state government and six members chosen by the board. An association studies its river system and decides how it shall be used. When it is determined what works are necessary to secure these applications, the organization designs, builds, and operates the installations. Revenues are obtained from taxes on

industries, communities, and water authorities, as well as from the sale of hydroelectric power, digested sludge, digester gas, and rights to utilize land. New construction is financed from bonds, which have a high investment rating.

Adoption of the river association idea would have many advantages. The whole water economy of a particular area could be dealt with as a unit designed to meet the best overall needs of the people. Long-range plans could be made to anticipate expansion and changing requirements, and pollution could be controlled in a rational manner to satisfy local needs. The cost of the program would be borne by those who benefit most directly, and, most important of all, water conservation would be managed by the district concerned, rather than by a distant, rather abstract, governmental agency. The association of persons with common interests has always been productive of best results.

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Correction

In presenting the 1954 utility safety record (August 1955 Journal, p. 762), an error was made in the last sentence. It now reads: "The severity rate remained practically static with rates of 0.093 and 0.95 for 1953 and 1954, respectively." The first figure should be "0.93."

A Combination of Ground and Surface Water for Industrial Supply

R. D. Wilson

A paper presented on Jun. 14, 1955, at the Annual Conference, Chicago, Ill., by R. D. Wilson, Partner, Wilson & Anderson, Cons. Engrs., Champaign, Ill.

An industry or a community often obtains part of its water from wells and part from surface storage or streams. Such a composite usually comes about, however, because the first-adopted source becomes inadequate, requiring an additional source. It is unusual when the original plan for a supply depends upon both surface and subsurface water. In the project discussed in this paper, a unique combination of sources, transmission, and storage were employed. This unprecedented arrangement seems likely to provide the most economical construction and operating cost for the plant served, while balancing reasonable usage against conservation of ground water.

The National Petro-Chemicals Corp. was formed in 1951 to build and operate a plant producing liquefied-petroleum gases and chemicals from natural gas. The location finally decided upon was a completely rural area about 4 miles west of Tuscola, Ill., the junction of two major gas transmission systems from Kansas and the Gulf Coast. An important repressurizing station, already in operation, could be used to return the gaseous residue to the pipeline. Other factors, such as availability of transportation, construction men, and land, were favorable to the selection of this site.

The plant, expected to process 400,000,000 cu ft of gas daily, in producing propane, butane, gasoline, and ethane, was designed with a steam and electric power unit, capable of generating 600,000 lb of steam per hour and 12,000 kw.

Preliminary estimates of water requirements for this $28,000,000 plant were 3,000 gpm initially and 5,000 gpm ultimately, most of which would be utilized in the form of makeup water for cooling. The total circulation rate, of course, would be much greater. There was no local source which could meet such demand. Because adequate ground water was expected to be found at a distance of not more than 25 miles, it was decided to go ahead with the project.

Search for Water

The search for water was undertaken by a drilling company which used as its principal guide a bedrock topography map of Illinois that had been prepared a few years earlier by the State Geological Survey. This chart indicated the presence of a large preglacial valley sweeping across east-central Illinois in a general east–west direction. This geologic formation, designated the

"Mahomet" or "Lower Teays" Valley, has attracted much attention in recent years as the prehistoric drainage outlet for an area including most of the territory now served by the Ohio River. It was known that tremendous, and probably continuous, deposits of water-bearing sand and gravel lay buried in parts of this valley, which is now filled with as much as 450 ft of glacial material. Water is obtained from these aquifers by several communities in Illinois, including Champaign-Urbana, which withdraws 5–7 mgd. Although the main valley was at least 20 miles from the proposed plant, the bedrock map indicated a principal tributary approaching much closer. Because virtually no exploration had been made of the closer tributaries and very little in the main valley at its closest point to the plant site, a test-drilling program was undertaken with considerable optimism.

The results of the undertaking near the proposed location were completely discouraging, and the drilling proceeded away from the site until good indications were found in the Mahomet Valley itself at least 20 miles away. Some of the most favorable test holes were found near the channel of the Kaskaskia River, which flows southward from headwaters near Champaign and passes as close as ½ mile from the Petro-Chemicals plant site. The river had been previously considered and rejected as an unsuitable source, but it later occurred to the chief engineer that a combination of a supply, when available, from the river and a supplement from wells, when needed, might be a workable, economical plan. The well water could possibly be carried in the stream channel, thus, avoiding at least $1,500,000 for a pipeline.

Results of Study

The idea was discussed with the State Water and Geological surveys and the US Geological Survey. Although encouragement was given by their engineers, it was pointed out that a detailed examination of the matter was required and that if the plan were proved sound from an engineering viewpoint, negotiations would be required with private owners, drainage districts, and other public and private agencies. An attorney, well informed and experienced in Illinois drainage law, gave his opinion that the plan was legally feasible. The author's firm, which undertakes drainage and water supply work, was particularly familiar with the area involved, and was engaged to make a preliminary study of the supply problem. This undertaking was done in great haste because all other plans were well advanced. The engineer's report set forth the following information:

1. The drainage area of the Kaskaskia River near the plant site is 130 sq miles. Flow-duration curves based on gaging-station records downstream indicated that without channel storage the river would meet or exceed initial plant requirements of 3,000 gpm 78 per cent of the time and ultimate requirements of 5,000 gpm, 70 per cent. The minimum flow for long periods of drought, however, would be nearly zero. Either the construction of a sizable reservoir, or the use of a supplemental supply would be necessary if the river were to be used as primary source of water.

2. No possibility existed for a large reservoir in the river valley or in a side channel. The river is a highly essential drainage outlet for some of

the flattest farm land in Illinois, and the main channel had been dredged and deepened from its headwaters to within a mile of the proposed plant. Even a low channel dam in the river near the site would be subject to question by farmers upstream. Fortunately, a 72-acre tract of land of low agricultural value lay between the selected location and the river. The topography of this area presented the possibility of forming a small reservoir which would hold about 50 mil gal after construction of an earth dam and levees. This amount appeared to be the minimum advisable storage, assuming that deficiencies of river flow would be made up from wells and not, generally, from the reservoir.

3. Studies of the stream route and profile showed that if the dredging and straightening of the channel were extended downstream below the reservoir tract, the effective depth and capacity of the passage could be increased enough so that a low control structure, needed for measuring the flow, could be placed in the watercourse without injuring drainage. A diversion channel to a deep pumping basin could be excavated from a point immediately upstream from the weir, thus, providing a small amount of additional storage.

4. A saving of about $1,000,000 in construction cost and about $50,000 per year in operating cost would be realized if well water could be transmitted without serious loss by the stream channel rather than by a pipeline. It was necessary to estimate how serious such loss would be and to determine if drainage, the primary purpose of the improved watercourse, would undergo interference.

5. There was no time to conduct field experiments, and applicable recorded data were scarce. Apparently, no one had previously used an Illinois drainage ditch as a dry-weather aqueduct. It was generally felt that the water would be dissipated by evaporation, transpiration, and percolation into the subsoils before completing the 25-mile journey to the plant intake. By using percolation data for a more porous clay subsoil than believed to be typical of the river bottom, and by taking into consideration standard evaporation rates, it was calculated that there would be a maximum loss of not more than 33 per cent of the water input, even if the stream bed were entirely dry except for the added well water. Such a condition was not known to have occurred in about 40 years, because the channel had been artificially deepened, prolonging the duration of seepage from adjacent fields. For the average, or normal, year, no appreciable transmission loss was anticipated.

6. Analysis of channel characteristics showed that the 16.5 cfs that would be required under the worst possible conditions in the smaller, upper section of the stream, would be only a fraction of the 350-cfs capacity of the ditch at full stage. A maximum depth of flow of about 1.7 ft would be necessary—just a small part of the 8-ft depth of the ditch. Downstream, of course, as the stream section increased (and the amount of water in transit diminished), the depth of flow and the percentage of ditch volume in use diminished to a minimum of about 0.7 ft and 1.4 per cent, respectively. No basis for conflict with drainage interests could be discovered, because it was determined that the plant would

have no reason to operate wells when the stream was producing as little as 2 per cent of its own hydraulic capacity. In fact, there were advantages in the proposed plan for the drainage districts and riparian owners, because the chemical company would contribute generously to the maintenance of the ditch, relieving the landowners of a large part of their drainage taxes.

7. The amount of mineral content and the treatment that would be necessary were established both for plain well water and for average quality of river water mixed with well water. Comparisons of the two possible types of supply were favorable to the latter. Turbidity and temperature were, of course, less troublesome in unmixed well water, but the plant could avoid use of the most turbid waters by stopping the intake pumps during very turbid stages. The high temperature, significant in hot weather, could be overcome at a reasonable cost by providing evaporative cooling facilities.

Agreements and Contracts

The proposed water supply plan was recommended and adopted. After the author's firm and the local attorney were authorized to initiate all necessary action, an unusual series of agreements and contracts were negotiated. It was certain that much opposition would be aroused at first, based either upon the assumption that the plan would interfere with drainage or that it would rob the Champaign-Urbana area of its due share of ground water to be used by an industry not in the economic sphere of these cities. A very helpful argument for the plan was that if full use of the river were not permitted to the chemical company, it would be obliged to acquire land, drill wells, and pump all required water from underground sources, thus making about three times the demand on ground water near Champaign-Urbana than would otherwise be necessary. This argument and others reduced nearly all opposition, so that all of the agreements were made within less than a year's time after the search for water began. These were the principal arrangements:

1. A 20-year contract was signed with three drainage districts having jurisdiction over the river channel to within 1 mile of the proposed intake and over several lateral ditches. The company promised to reconstruct and maintain the entire system (about 38 miles of channel) of open ditches of these districts in exchange for the use of the channels for transmission of water in times of drought and low flow. The details of these agreements were carefully drawn to comply with Illinois drainage statutes and to protect both parties against unreasonable usage or obligation.

2. An agreement was made with Champaign-Urbana and the water utility that serves it from wells in the buried valley. The chemical company agreed to limit its withdrawal of ground water, both in amount and in well location, so that the community's supply would not be jeopardized. Two observation wells equipped with water level recorders were built by the company and are maintained by the State Water Survey to determine any interference between wells of the water utility and those of the manufacturing concern.

3. The options and agreements under which exploratory drilling was completed and permanent wells were built provides that there will be no damage to farm wells within 1 mile of company wells and that all necessary changes of such wells and pumping equipment will

be made, or new wells drilled, to assure continuation of supply to the adjacent farms. All of the sixteen nearby farm wells were examined to determine conditions that existed prior to operation of the company wells, and this information was recorded with the State Water Survey. Abandoned farm wells and one special observation well in the area are checked at regular intervals to ascertain the water levels, and these data are also filed with the survey.

4. Agreements were made with seven private owners having riparian rights on the Kaskaskia River near the plant intake obligating the company to improve a 2-mile section of the stream by clearing and dredging in exchange for permission to use the stream channel for transmission of well water.

5. One of the drainage districts agreed to sponsor the operation of a flow-gaging station on the river just beyond the reservoir intake. Because this station, built by the company, is operated by the US Geological Survey in conjunction with other stations in the state, the recorded flow is a matter of public information.

6. As a part of the principal agreements the company is obliged to measure and record all water usage and to file such data monthly with the State Water Survey. The utility supplying Champaign-Urbana is similarly required to inform the company about its pumping operations and water levels. Thus, there is being assembled a correlated set of facts which will be useful to everyone concerned whenever new arrangements are to be made or disputes arise.

The many contracts were generally necessary because Illinois has no statutes governing ground water usage and the rights of usage of streams are not well defined. Disputes may be referred for arbitration to the State Water Resources and Flood Control Board, authorized in 1945. Because its authority has not been tested, however, voluntary agreements and the authority of the County Court with reference to drainage districts were mainly relied upon for legal protection. No rights of eminent domain were involved, because the company was not itself a public utility. If voluntary understandings had failed, however, the possibility of turning the problem over to such an agency was an alternative procedure.

Final Design

The final design and construction of the water supply system was not as difficult as it was unusual. Test drilling led to the fortunate discovery of locations for two or more good wells on stream banks. Two 36-in. gravel-packed wells, about 275 ft in depth, were built, each capable of producing over 5 mgd if necessary. To keep water lift at a reasonable rate, however, one is equipped to pump only a maximum of 2,200 gpm, and the other, 2,700 gpm. The placement of a third well has been determined, but has not yet been built.

It was decided that the reservoir should have a capacity of 100 mil gal, regardless of the apparent limitations of the site. The design adopted required the excavation of 352,000 cu yd of earth, more than half of which was distributed on adjacent high-ground and river bottom areas. Because the reservoir is almost completely surrounded with levees, the normal water level is a few feet higher than the lowest natural ground at each side of the nearly rectangular tract. The earth dam separating the reservoir from the river bottom and intake basin has a maximum height of 21 ft. The normal

crest elevation of the spillway is 24 ft above low water in the river. Two pumps of 3,500-gpm capacity at a head of 26 ft are installed in a reinforced-concrete intake structure located at the end of a diversion channel and intake basin leading from the river. There is space for two more pumps at the intake.

Practically all construction work and installation was completed within 1 year after the conclusion of the necessary agreements, including the clearing and redredging of 38 miles of ditch channels and almost 2 miles of river channel near the plant. Flow to the reservoir began in January 1953, and it was filled the following March without the addition of well water.* Production of chemicals began in July 1953.

Test of Project

Coincident with the initial operations of the plant, the results of a severe drought began to limit natural stream flow and put the dual system to immediate test. Pumping from the wells began on Aug. 3, 1953. Locally, the Illinois drought actually had begun in April. By the end of December, the shortage of rain for the preceding 9 months was 13.53 in., or a 50 per cent deficiency from a normal total of 26.60 in. Conditions eased slightly early in 1954, but depleted shallow ground water storage and subnormal rainfall necessitated almost constant use of well water until Nov. 26, 1954, after which intermittent pumping was sufficient to Feb. 12, 1955. At this date both well pumps were stopped and the plant has had adequate river water since, although rainfall has continued somewhat below average.

The 15½ months of almost constant pumping from August 1953 to November 1954, together with other usage in the Champaign-Urbana area, caused a temporary recession of 11–13 ft in the well field within about ½ mile of the wells. Recovery in the 4 months after pumping had been stopped has been so rapid that the water level at the walls is now only 2 ft below the static level of August 1953. Recovery is continuing at the rate of about 0.5 ft per month at the present time.

The recent drought has afforded an early and effective test of the production and transmission plan adopted for the plant. The transmission loss in August 1953, gaged at about 10 per cent of input, is now expected to be about the maximum loss for any likely condition. Analyses of precipitation and stream flow records indicate that there will be many years in which little or no pumping from the wells will be required in order to meet demands. Because expansion of the plant is now underway, some increase of the anticipated ultimate water demand figure is expected.

The relative economy and success of the combination source of supply encouraged Decatur, Ill., to adopt in 1954 a similar emergency solution to a shortage that could not be relieved by other means for a considerable length of time. State agencies interested in economical use and conservation of resources continue to support the method discussed in this paper as an example of practical conservation worked out voluntarily without statutory rules and regulations. The author feels that the practicability of similar procedures can be shown under specific circumstances.

* Actual operation of the water system was turned over to the Industrial Water Supply Co. (see p. 871).

Discussion

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R. D. Wilson has very clearly outlined the plan to obtain an adequate and satisfactory source of water for a plant which was to be located rather far from any existing source of adequate supply.

Shortly after the source and treatment facilities were decided upon, the Illinois Cities Water Co., owner of the public water system in Tuscola, Ill., made an agreement with National Petro-Chemicals Corp. to purchase its entire water production and waste treatment installations. The Industrial Water Supply Co. formed to operate this system is one of the few companies furnishing water solely to a large industry. Because this water works does not sell water to the public, it is not under the regulations of a utility commission.

The treatment plant began supplying the early construction demand of National Petro-Chemicals Corp. in January 1953. The supply was obtained from the river as natural runoff until August. From then until February 1955 there was not a month in which the wells were not used to supplement the natural river flow. In June 1954, only about 9 mil gal of well water was required, whereas in September 1954, 178 mil gal was needed In December 1953 and January 1954, 5.6 mgd was used by the plant. During this time the river froze over, restricting the natural flow, and water had to be pumped from the wells to keep an adequate supply at the intake.

Inasmuch as it takes the water about 36 hr to go from the wells to the river lift station, the flow is difficult to regulate, especially if pumping is required in seasons when normal rainfall can be expected. If the wells are operating at the time of a heavy rain, water has been unnecessarily pumped. Waste also occurs during the winter months when much of the flow is retarded by freezing, because withdrawal capacity is often exceeded after warm-weather thawing.

The Northern Illinois Water Corp., which also makes use of the Lower Teays Valley in supplying Champaign-Urbana, has found that the withdrawal from the Industrial Water Supply wells, located about 2½ miles south of its own wells, affects their water level. During a period of heavy pumping, the level dropped about 3.5 ft in the Northern Illinois Water Corp. wells.

The treatment of industrial waste from the National Petro-Chemicals Corp. is sometimes of great importance, particularly during the low periods of flow. Used water was customarily returned to the river about 500 ft below the plant intake. The natural flow was restricted at times because of the construction on new pipeline crossings and highway improvements. These blocks caused the impounding of the waste water, and in order to prevent its backflow into the fresh-water intake, sufficient clean well water had to be allowed to go over its weir at a rate great enough to prevent such an undesirable reversal of flow. This loss of well water, as great as 40 per cent, was of concern to the Northern Illinois Water Corp.

The underground supply has substantially recovered. No pumping has been required since Feb. 12, 1955, the

end of the most severe drought in more than 50 years.

Wilson discussed the maintenance of the 38 miles of channels in the various drainage districts. Annually, between May 10 and Jun. 10, the inside slopes of these channels must be sprayed with a herbicide to kill the vegetation, a procedure which has given very good results. Every 10 years the main watercourse will have to be redredged to remove obstructing silt.

The dual water supply system, a very unusual arrangement, has been in operation for more than 2 years, part of the time in a period when there was only about 50 per cent of the normal rainfall in the area. The industrial demand for water, however, was unfailingly met.

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Aeration of Water

Revision of 'Water Quality and Treatment,' Chapter 6

A revision of Chapter 6 of the second edition of Water Quality and Treatment *(American Water Works Assn., New York, 1950), prepared by AWWA Committee E5.B1—Revision, Chapter on Aeration. The members of the committee were: G. R. Scott (Chairman), Q. B. Graves, P. D. Haney, Lawson Haynes, J. E. McKee, Malcolm Pirnie Jr., G. J. Rettig, and J. H. Svore.*

1. Introduction

IN water treatment practice, the term "aeration" is applied to those processes in which water is brought into intimate contact with air for the purpose of changing the concentrations of volatile substances contained in the water. M. N. Baker (*1*) states:

> In the eighteenth century, artificial aeration was directed at making up the oxygen deficiencies of distilled water and of rain water that had been stored in household cisterns. Toward the end of the eighteenth century and early in the next, aeration was applied to a few public water supplies carrying decomposed vegetable or animal matter. Not until the last half of the nineteenth century did aeration become a marked feature of municipal supplies. Even then, the number of applications was small and pertained chiefly to stored waters subject to taste and odors from algae growths. In this period, aeration was applied here and there, generally to ground waters, for the removal of iron, and then of manganese, and also to eliminate malodorous gases from sulfur-bearing ground waters.

The inventory of water treatment plants prepared by the US Public Health Service in 1948 lists 1,574 plants having aerators (*2*). This is the breakdown as to type:

Cascade	462
Trays	365
Spray	182
Patented types	118
Combinations	52
Unspecified	395

2. Purpose

The basic purpose of aeration is the improvement of the physical and chemical characteristics of water for domestic, commercial, and industrial use. The accomplishment of this intent requires in some cases a decrease and in others an increase in the concentrations of volatile substances in the water.

Substances that may be decreased by aeration include:

a. Substances that produce tastes and odors, such as hydrogen sulfide and some volatile organic compounds.

b. Substances that increase the corrosive action of water, such as carbon dioxide and hydrogen sulfide. Although oxygen may also be considered in this category, its concentration is seldom decreased by the usual aeration processes under the conditions of temperature and pressures encountered in water treatment plants.

c. Substances that react or interfere with chemicals used in the treatment of water. These materials include carbon dioxide in softening and iron re-

moval processes and hydrogen sulfide before chlorination.

d. Miscellaneous gases, such as methane.

Substances that may be added to water by aeration include:

a. Gases from the atmosphere, particularly oxygen, which is useful in the improvement of taste and odor and for the oxidation of iron, manganese, hydrogen sulfide, and, to a limited extent, organic matter.

b. Substances that alter the characteristics of water in preparation for a subsequent processing step. In the recarbonation process, after softening with excess lime, carbon dioxide is added by an aeration device for the neutralization of causticity. Carbon dioxide is also added at times during aeration to waters high in sulfides in order to lower the pH value and thereby increase the volatility of hydrogen sulfide for more effective removal.

3. Limitations

Aeration generally is not an efficient method for the removal or reduction of tastes and odors because most of the substances causing the undesirable traits are not sufficiently volatile. When the volatility is adequate, however, these substances can be removed by the process.

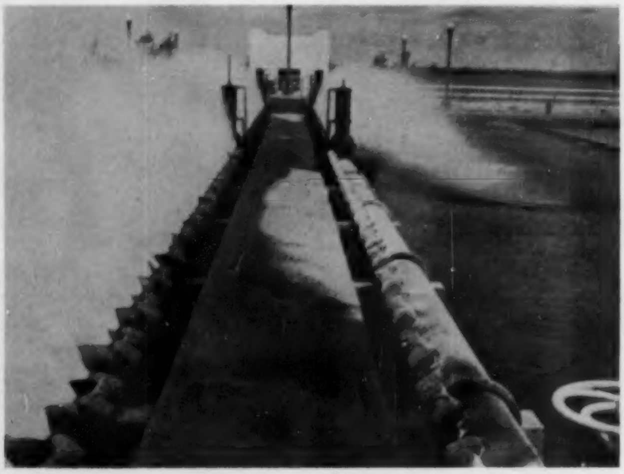

Fig. 6-1. Spray Aerators

The installation shown is at West Palm Beach, Fla. Spray aerators require such a large area that they cannot be housed economically, and they generally are not used during freezing weather.

The essential oils of algae—released as the organisms disintegrate—are not highly volatile and, hence, are not satisfactorily removed by aeration alone. Odor removals of only 50 per cent have been reported where *Synura* was the causative organism. Among those reporting that aeration alone has not been successful in the satisfactory reduction of tastes and odors caused by algae are the plant at Denver and the

Oklahoma A. & M. plant at Stillwater, Okla. Others report satisfactory operation, but indicate that activated carbon is also used for taste and odor reduction. A number of plants in Ohio (Akron, Barberton, Fremont, Nelsonville, Piqua, and Wellston) have discontinued the practice because aeration either has been ineffective or has aggravated the trouble. The plants at San Diego, Calif., Bloomington, Ill., and Riverdale, N.J., also report that the use of aerators for taste and odor reduction has been discontinued.

Tastes and odors caused by chemicals carried by some industrial wastes may be aggravated by chlorination. Although not satisfactorily reduced by direct aeration, some of these odors may disappear after storage of a few days following aeration (*3*).

The most important functions of aeration are the removal of carbon dioxide from water prior to lime-soda softening and the addition of oxygen for the removal of iron and manganese. The benefits in these processes, however, are not always obtained completely without adverse effects. In some plants the oxygen entering solution during the aeration process renders the water more corrosive (*4*). Lansing, Mich., reported that during aeration of well water for the reduction of carbon dioxide prior to softening and iron removal, numerous complaints of red water in hot-water systems were received; after aeration was discontinued and the carbon dioxide was neutralized with lime in the regular plant treatment process, the complaints ceased and did not recur. Ann Arbor, Mich., and LaGrange, Ill., have also discontinued aeration in order to stop formation of red water.

Aeration alone is usually sufficient to cause precipitation of iron and manganese when organic matter is not present (*5*). When such material is present, it combines with the iron and manganese to form complex compounds which do not precipitate satisfactorily after aeration. In such instances it has been found that moderate rather than vigorous aeration gives better results.

The use of aerators after treatment or as the sole treatment for well waters should be examined quite critically, particularly as the water is subjected to airborne contamination. At one plant, filtered water enters the reservoir through spray nozzles throwing the water from 12 to 14 ft into the air. During 1949, the effluent contained coliform organisms although tests on the influent were negative. West Palm Beach, Fla., abandoned aerators because chironomids laid eggs on the surface of water in the basins and the larvae or bloodworms, after hatching, appeared at the consumer taps.

In supplies where the carbon dioxide content of the raw water is low, or where other treatment processes are relied upon to remove or reduce tastes and odors, the cost of aeration should be compared with that of chemicals required to accomplish the same purpose. If the main purpose of aeration is taste and odor reduction, it is quite probable that no additional chemicals will be required when aeration is discontinued. On the other hand, additional lime will be required to neutralize the carbon dioxide that would be removed by aeration. An exception (*6*) to this general statement is found at Appleton, Wis., where the reduction in threshold odor by aeration during August and September is about 23 units, while during October and November, when the water is colder, the reduction is from 3 to 5 units. Aeration is economical in the warmer

months, but is of questionable value during October and November. Another exception is the installation at the Nitro, W.Va., plant of West Virginia Water Service Co. (*7*).

About 10 ft of head is required for many of the waterfall aerators, and air must be compressed to about the same extent in the diffused-air type. The power requirements for the two do not differ materially and—for the purpose of the following comparison—are taken as 39 kwhr per million gallons, or the requirement for pumping based on 80 per cent efficiency. Theoretically, 1 ppm carbon dioxide requires 5.9 lb of 90 per cent quicklime per million gallons for partial neutralization to calcium *bicarbonate* and 11.8 lb per million gallons for complete neutralization to calcium *carbonate*. If the cost of power is $0.01 per kilowatthour, the operating expense of aeration will be approximately $0.39 per million gal-

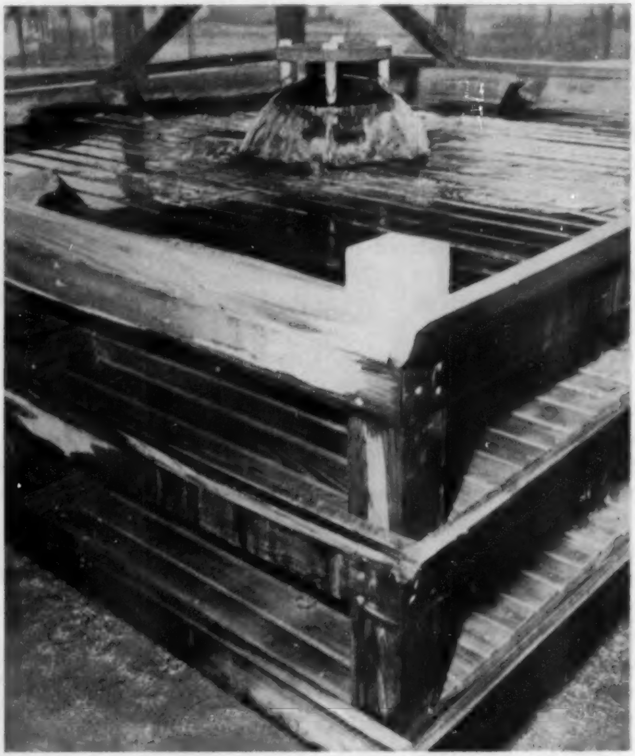

Fig. 6-2. Multiple-Tray Aerator

This slat-bottomed unit—in use in Duval County, Fla.—produces good turbulence and exposes a large water surface area to the atmosphere. The illustration is taken from a paper by S. W. Wells (8).

lons. If lime costs \$0.008 per pound, the cost per million gallons for removing 1 ppm carbon dioxide by complete neutralization is \$0.095. For partial neutralization, the cost would be one-half this amount. If the reduction of carbon dioxide is no more than approximately 4–8 ppm, it may be more economical to discontinue the use of aeration. Baylis (*9*) is of the opinion that where the carbon dioxide content is approximately 10 ppm or less, it is usually cheaper to neutralize with lime or soda ash than to employ aeration.

4. Theory

The relative amounts of the volatile substances contained in air and water and their concentrations in water with respect to their saturation value are factors that control the rate at which the interchange takes place. Substances that occur in water in amounts less than or in excess of their saturation values are changed in concentration by aeration, with the saturation value the limit of change for both conditions.

The substances involved in the reaction must be volatile, as are oxygen, carbon dioxide, and hydrogen sulfide; their concentrations in water are readily affected by the process. Many of the taste- and odor-producing compounds occurring in water as the result of algal growths or industrial wastes are not volatile at the temperatures encountered in natural waters and cannot be removed by aeration. As higher temperatures increase the volatility of the compounds and decrease their saturation values, aeration for the removal of volatile materials is more effective in warm than in cold waters.

The interchange of the substances from water to air or vice versa takes place at the air-water surface. The rate at which transposition occurs is the result of the relative concentrations of the substance at this surface and the rapidity with which new surfaces are formed and exposed. Because molecular diffusion of gases through liquids occurs at low rates which exert little effect on the efficiency of the process, all types of aerators, to be efficient, must develop and continually change large surface areas where fresh contacts are made and through which the interchange may take place.

The exchange can be described by these formulas, based on equations given by Lewis and Whitman (*10*) and discussed by Haney (*11*):

a. Gas absorption:

$$C_t = S - (S - C_0)10^{-k(A/V)t} \quad (1)$$

b. Gas release:

$$C_t = S + (C_0 - S)10^{-k(A/V)t} \quad (2)$$

These formulas and the differential equations from which they are derived indicate that:

a. At any instant, the rate of gas transfer is directly proportional to the difference between the gas saturation concentration (S) and the actual concentration (C_t) in the water.

b. The rate of gas transfer is directly proportional to the ratio of the exposed area to the volume of water (A/V).

c. The rate of gas transfer is directly proportional to the gas transfer coefficient (k) which, in turn, is dependent on the diffusivity of the gas in question and the film resistance.

d. The total amount of gas transfer is greater as the time of aeration increases.

e. The percentage change in gas saturation deficit ($S - C_t$) or surplus ($C_t - S$) for any given time period

(t) is constant, based on the deficit or surplus at the beginning of the time period.

f. Temperature and pressure are important factors because they influence gas solubility (S). Temperature also influences diffusivity and film resistance and, hence, the value of k.

The term C_0 is the concentration of gas originally present in the water.

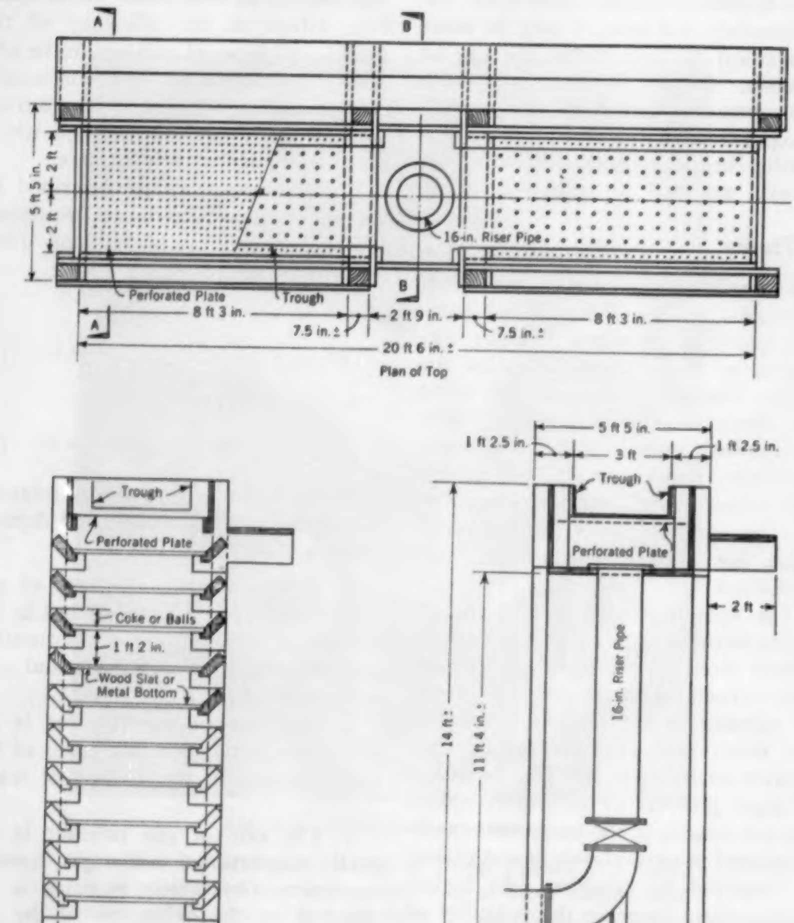

Fig. 6–3. Details of Multiple-Tray Aerator

The two tiers of trays are supplied from a central riser pipe. The illustration is taken from a paper by R. L. Brown (12).

5. Design and Operating Data

The time factor and the ratio of surface area to the volume of water, A/V, are important considerations in the design of an aerator. The partial pressure or the concentration in the air of the gas to be removed must also be considered and provision made for ventilation in installations where the unit is to be housed.

Aeration equipment used in present practice employs one of two methods to control time and A/V. One exposes water films to the air and the other introduces air in the form of small bubbles in the water. The first is generally known as the waterfall type and the second as the diffused-air type.

Because waterfall aerators—as the name implies—require that the water be dropped in the process, their use results in the loss of a considerable amount of head. On the other hand, although little or no loss of head is required for the diffused-air units, they require the expenditure of energy in compressing the air and forcing it through small orifices into the water at some distance below the surface.

Difficulties in the operation of waterfall aerators can be expected from freezing during the winter in extreme climates unless they are housed. If an aerator is enclosed, careful consideration must be given to ventilation in the interest of efficiency and safety.

The work of Brown (*12*) at Memphis demonstrated that good ventilation is necessary for the effective removal of gases from solution. His conclusion, based on data from pilot and full-scale plant operations, was that the media in multiple-tray aerators should be so arranged that fresh air continuously passes through the falling water and over the media. He further concluded that it was impossible to secure consistent results with an aerator dependent on natural ventilation alone. Better removals were obtained when a breeze was blowing than when a calm prevailed.

Ventilation for an enclosed aerator is also of importance from a safety standpoint in the removal of carbon dioxide, methane, and hydrogen sulfide. The first named is an asphyxiant, the second creates an explosion hazard, and the third is highly poisonous.

As corrosion of the structure and equipment represents a major consideration in the design of aerators, materials which will resist the action of the water must be used. Concrete, aluminum, asbestos-cement, copper-bearing steel, stainless steel, and creosoted lumber have been used in the construction of aerators. Bronze and cast iron are used in nozzles and a number of patented devices. Ordinary steel should be used only in those locations that are readily accessible for painting at frequent intervals.

Because slime and algal growths may be troublesome in waterfall aerators of the cascade and tray types—especially if the units are located outdoors and subject to sunlight—treatment by chlorine or copper sulfate may be necessary.

6. Waterfall Aerators

a. Spray aerators. Spray aerators consist of fixed nozzles on a pipe distribution grid, through which the water is forced into the air, as in a fountain (see Fig. 6–1). Spray aerators possess great public appeal and aesthetic value. They require such a large area that they cannot be housed economically, and they generally are not operated during freezing weather.

The time of exposure of each droplet of spray depends upon its initial veloc-

ity and its trajectory, while the size of the droplet (and consequently its surface area–volume ratio, A/V) is a function of the dispersing action of the nozzle.

The initial velocity is given by the equation:

$$V = C_v \sqrt{2gh} \quad \ldots\ldots\ldots (3)$$

and the discharge by the equation:

$$Q = C_d a \sqrt{2gh} \quad \ldots\ldots\ldots (4)$$

The trajectory of the spray may be vertical or inclined. If θ represents the angle between the initial velocity vector and the horizontal, the theoretical time of exposure of the droplet is given by the equation:

$$t = 2C_v \sin\theta \sqrt{\frac{2h}{g}} \quad \ldots (5)$$

As the sine of an angle less than 90 deg is less than 1.0, it is apparent that the vertical jet gives the longest time

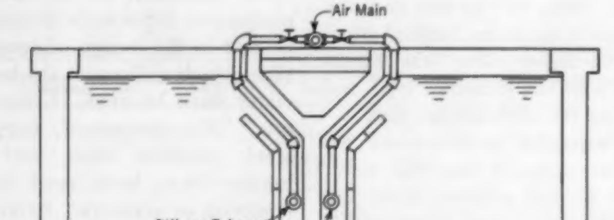

Fig. 6-4. Diffused-Air Unit

For an equal expenditure of energy, this aerator provides a longer aeration time than the waterfall type.

in which h is the total head on the nozzle; g is the acceleration of gravity; a is the area of the opening; C_v is the coefficient of velocity; $C_d = C_v C_c$ is the coefficient of discharge; and C_c is the coefficient of contraction. The coefficients of velocity, contraction, and discharge vary widely with the shape and other characteristics of the orifice or nozzle.

of exposure for a given head. The inclined jet, however, has a longer path of travel, resulting in less interference among the falling droplets.

The design of the nozzle is extremely important in achieving optimum dispersion of the water. Nozzles vary from those with plain tips to those which impart a whirling motion to the water. Among the special designs are

the rifled nozzle, the centrifugal (West Palm Beach) nozzle, impinging devices, Sacramento floating cones, and rotating reaction nozzles similar to certain lawn sprinklers.

The size, number, and spacing of the nozzles depend upon the head and the area available for aeration. Nozzles generally used are from 1 to 1½ in. in diameter, as smaller nozzles tend to clog and require excessive maintenance. The discharge ratings vary from about 75 to 175 gpm at 10 psi and the spacing varies from 2 to 12 ft. The area required appears to range from 50 to 150 sq ft per million gallons per day of capacity.

Although spray aerators are spectacular and provide a high surface-volume ratio in the fine droplets, the time of exposure is very short (about 2 sec for a vertical jet operating under a head of 20 ft), and this type is no more efficient than others requiring less space.

Table 6-1 lists the pertinent details of construction and gives the results of carbon dioxide removals of a number of typical spray aerators. Flentje (*13*) reports that, in general, spray aerators will remove from 70 to 80 per cent of the carbon dioxide and that removals as high as 90 per cent have been experienced.

TABLE 6-1

Typical Spray Aerators

Installation	Design Capacity *mgd*	Number of Nozzles	Spacing *ft*	Type	Pressure *psi*	Space per Unit of Capacity *sq ft/mgd*	Operating Results		
							Flow *mgd*	CO_2—*ppm* Raw	CO_2—*ppm* Aerated
Contra Costa, Calif.	12	42	4	Sacramento	1.64	138			
Denver, Colo.* North Side Filter Plant	64	600	3	special	11.27	85	64	trace	0.5
	100	600	3	special	6.50	54	100	trace	0.5
Jacksonville, Fla.†									
Main St.	12.95	200	2.5	floating cone	0.98	97	7	10	4
Hendricks Ave.	7.30	26	6	adjustable cone	1.19	129	2	8	4
West Palm Beach, Fla.‡	20	202	2,3	West Palm Beach	10	78	variable	3.7	12.9
Bangor, Me.§	8	80	2 to 2.5	patented	3	50	4.25	7.5	
Lawrence, Mass.‖	10	70	10	Sacramento	1.73	700			
Springfield, Mo.‖	5.6	39	12	patented	17	1,000			
Appleton, Wis.#	8	72	3.5 × 4	patented	2.3	128			

* Surface supply essentially free of carbon dioxide.
† Supply from deep wells, all containing hydrogen sulfide in concentrations from 1.5 to 2.0 ppm; aeration removes from 25 to 40 per cent and supplies oxygen for oxidation of remainder.
‡ Supply from shallow lakes; aeration for reduction of algal odors; carbon dioxide reduction for iron removal; alum added prior to aeration, which accounts for high carbon dioxide content of aerated water.
§ Surface supply; aerator for reduction of carbon dioxide and nitrogen trichloride; aerated water contains about 15 ppm free chlorine.
‖ Surface supply; aerator for reduction of algal odors.
\# Surface supply; aerator for reduction of algal odors; average reduction of threshold odor from 24 to 51 per cent reported; alum added prior to aeration.

Not listed in Table 6-1, but worthy of mention, is the installation of the Nitro plant of the West Virginia Water Service Co., Charleston, W.Va. (*7*). Threshold odors of 5,000–6,000, caused by industrial wastes, have been encountered in the raw water. The primary aerator operates 12–16 hr per day with pressures at 55 psi, while the water from the collecting basin is re-

circulated through the sprays for the remainder of the 24 hr. Water is also drawn from this basin and forced through a second set of sprays at a pressure of 25 psi before going through the rest of the treatment processes. From 97 to 99 per cent of the odor is removed by the aeration procedure, leaving a threshold odor of approximately 60 to be removed by other means.

b. Cascade aerators. Many varieties of cascade aerators are in use. The general principle is to spread the water as much as possible and let it flow over obstructions to produce turbulence and to change water surfaces in contact with the atmosphere. The simplest unit is a concrete-step structure which spreads the water and allows it to fall from one level to another. Some commercial equipment is constructed in the form of circular trays with shallow weirs on their periphery. The water, spread in the shallow trays, flows in thin sheets over the weirs as it drops from an upper to a lower tray.

The surface area–volume ratio and the time of exposure in a cascade aerator are difficult to evaluate. The time of exposure can be extended by increasing the number of steps and the surface area–volume ratio can be improved by adding obstructions to increase turbulence. Generally, the head required varies from 3 to 10 ft. The cascade aerator at Champaign–Urbana, Ill., reduces carbon dioxide from 44–55 to 27–34 ppm and, at Ames, Iowa, from 18.6 to 10.4 ppm. The floor space occupied by the Illinois unit is 45 sq ft per million gallons per day of capacity; that taken up by the Iowa unit is 86 sq ft. The area of the unit at Oklahoma A. & M. is 38 sq ft per million gallons per day. Flentje (*13*) reports that removals of carbon dioxide by cascade aerators vary from 20 to 45 per cent. Where climatic conditions make it necessary, these installations can be housed to provide for winter operation.

TABLE 6–2

Typical Multiple-Tray Aerators

Installation	Design Capacity *mgd*	Area of Trays *sq ft*	Type and Size of Media	Number of Trays**	Vertical Distance Between Pans *in.*	Housing	Space per Unit of Capacity *sq ft/mgd*	Operating Results		
								Flow *mgd*	CO_2—*ppm* Raw	CO_2—*ppm* Aerated
Naples, Fla.*	1.1	81	2-in. coke	4	18	outside	74	0.67	28	4
Wichita, Kan.†	48	986	2-in. coke	5	18	inside	21	30	21	7.9
Owensboro, Ky.‡	10	280	coke	6	14	outside	28	5.4	34	8
Columbia, Mo.§	3	160	none	5	18	outside††	53			
Marshall, Mo.‖	2	80	none	6	18	inside	40	1.03	28	10
Memphis, Tenn.										
Allen station#	30	896	3-in.–6-in. coke	10	15½	inside	30	10.5	96	3.2
Sheehan station#	30	690	coke	6	16	inside	23	22.6	38	10

* Removal of hydrogen sulfide and carbon dioxide.
† Removal of carbon dioxide; has forced draft ventilation at rate of 29,500 cfm.
‡ Removal of carbon dioxide.
§ Removal of hydrogen sulfide.
‖ Removal of carbon dioxide; has forced draft ventilation at rate of 2,000 cfm.
Removal of carbon dioxide; natural ventilation through open walls.
** Including distribution pan.
†† With roof and screen sides.

c. Multiple-tray aerators. Multiple-tray aerators consist of a series of trays

equipped with slat, perforated, or wire mesh bottoms over which water is distributed to fall to a collection basin at the base (see Fig. 6–2 and 6–3). In most aerators, coarse media such as coke, stone, or ceramic balls—ranging from 2 to 6 in. in size—are placed in the trays to increase efficiency. These types produce good turbulence and expose a large water surface area to the atmosphere. The time of contact can be increased by the addition of more trays. Coarse media are especially efficient when used as a preparatory step in the removal of iron and manganese, because the media become coated with films which catalyze oxidizing reactions of the minerals to cause their precipitation.

From three to five trays are frequently used, with the spacing between them varying from 12 to 30 in. The area required for the trays appears to vary from 23 to 73 sq ft per million gallons of capacity, with most of them requiring less than 30 sq ft. Housing for this type of unit is less expensive than for the spray and cascade ones because of the smaller space requirements.

Information on a number of typical multiple-tray aerators is given in Table 6–2. The rate at which carbon dioxide is removed by these can be approximated by this empirical formula:

$$C_n = 10^{-Kn} C_0 \ldots\ldots\ldots (6)$$

C_n is the concentration of carbon dioxide (parts per million) after passing through n trays (including the distribution pan); C_0 is the concentration of carbon dioxide (parts per million) as determined originally in the water in the distribution pan; K is a coefficient (apparently ranging from 0.12 to 0.16) which depends on the amount of ventilation and other characteristics of the unit.

The similarity of Eq 6 to Eq 2 should be noted. The former does not contain the quantity S which appears in Eq 2, but as this is only about 0.5 ppm, its omission results in no significant decrease in accuracy of the expression for raw water containing more than approximately 10 ppm carbon dioxide. The value of K in Eq 6 is equivalent to the A/V in Eq 2, and n in Eq 6 takes the place of t in Eq 2.

Wells (*8*) reports 35–45 per cent removal of dissolved sulfides by multiple-tray aerators with slat bottoms in Duval County, Fla.

7. Diffused-Air Aerators

For an equal expenditure of energy, a unit of the diffused-air type provides a longer aeration time than the waterfall type because the rising bubbles have a lower average velocity than the falling drops. From the standpoint of gas exchange, this is a distinct advantage in favor of the diffused-air method. Other factors, including turbulence, surface area–volume ratio, and surface film thickness, however, also influence aerator performance; the waterfall type has the advantage in these respects. Diffused-air aerators conserve the hydraulic head and are not subject to freezing. On the other hand, they frequently have higher initial costs and may require greater expenditures for maintenance than waterfall aerators. When making a choice between the two types for any specific installation, due consideration must be given to the factors relating to the efficiency of operation in addition to those concerned with the cost and adaptability.

Diffused-air units generally consist of rectangular concrete tanks in which perforated pipes, porous diffuser tubes or plates, or patented impingement devices are inserted near the bottom (see

Fig. 6–4). Compressed air is injected through the system to produce fine bubbles which—on rising through the water—produce turbulence, resulting in a continual change of exposed surface. Tanks are commonly 9–15 ft deep and 10–30 ft wide. Deeper tanks require higher air compression, which adds to the cost of operation without corresponding improvement in the efficiency, as the rising bubbles expand and tend to coalesce. Shallower depths reduce the time of contact of the bubbles with the water and the effectiveness of the process. Ratios of width to depth should not exceed 2:1 if effective mixing is to be obtained. The length of the tank is governed by the desired retention period, which usually varies from 10 to 30 min.

The air diffusers are generally placed along one side of the tank to impart a spiral flow to the water, thereby creating turbulence and assisting in gas transfer. If porous tubes or perforated pipes are used, they may be suspended at about one-half of the depth of the tank to reduce compression heads. If porous plates are used, they are located on the bottom of the tank. The amount of air required depends upon the purpose of the aeration, but generally varies from 0.01 to 0.15 cu ft per gallon of water treated. Sufficient diffuser capacity must be provided to supply air at this rate without excessive head loss. Lateral baffles are used in some cases to prevent short-circuiting through the basin.

The blower pressure required depends upon the depth at which the diffusers are placed and the friction loss through the air distribution system. Power requirements vary from 0.5 to 2.0 kw per million gallons per day of capacity, with an average of about 1.0 kw.

TABLE 6–3

Typical Diffused-Air Aerators

Installation	Capacity *mgd*	Period of Aeration *min*	Objective	Air Requirement *cu ft/gal*	Power Requirement per Mgd of Capacity *kw*
Petersburg, Ind.*	1.0	30	odor removal–mixing	0.10	1.46
Huntingburg, Ind.*	0.4	8.5	odor removal	0.15	0.75
St. Paul, Minn.†	48	0.16	odor removal–mixing	0.01	
Brownsville, Tex.*	4	14	gas removal–mixing	0.07	0.48
Fort Atkinson, Wis.*	0.75	18	iron & odor removal	0.16	1.87
Kenosha, Wis.†	11.6	0.21	odor removal	0.01	

* Data from Roe (*14*).
† Activated carbon also used for odor removal.

When porous diffusers are used, incoming air should be filtered carefully through an electrostatic unit or a filter of metal wool, glass, or hair impregnated with oil, in order to minimize clogging.

Diffused-air aerators require less space than spray aerators and more than tray aerators. As there is usually no difficulty, however, in operating diffused-air tanks during the winter, the need for housing is eliminated. The space for a tank 15 ft deep—providing a retention period of 10 min per million gallons per day of capacity

—is 62 sq ft per million gallons per day. Longer retention periods—required when the unit is used for mixing chemicals—require proportionately more space. A list of typical installations is given in Table 6–3.

8. Patented Types

In addition to the general types of installations discussed, there are a number of patented kinds which can be purchased from manufacturers. No attempt will be made here to describe these units. Information about them should be secured from the operating and design data of the suppliers.

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Reprints of 'Water Quality and Treatment' Revision

As a new edition of *Water Quality and Treatment* will not be published for at least several years, reprints of this revised chapter will be distributed without charge to future purchasers of the current (second) edition of the book, which may be obtained from the Association for $5.00 per copy ($4.00 to members paying in advance). Reprints will also be made available for purchase at a later date. Further details will be announced in a future issue of the JOURNAL.

Development of a Fresh-Water Barrier in Southern California for the Prevention of Sea Water Intrusion

Finley B. Laverty and Herbert A. van der Goot

A paper presented on Jun. 14, 1955, at the Annual Conference, Chicago, Ill., by Finley B. Laverty, Chief Hydr. Engr., and Herbert A. van der Goot, Supervising Civ. Engr., in Charge of Hydr. Div., Water Conservation Sec., both from Los Angeles County Flood Control Dist., Los Angeles, Calif.

SEA water has been displacing valuable fresh water supplies in a great number of coastal ground water basins of the United States at an alarming rate and is threatening such derangement in many other basins. This phenomenon is not uncommon elsewhere in the world where the overdevelopment of coastal ground water supplies has upset nature's balance, reversing normal fresh water gradients and permitting sea water to degrade the fresh water. Such intrusion will eventually destroy the usefulness of the entire ground water reserves of the affected basin unless preventive measures are undertaken. Through personal contact and correspondence with engineering personnel from various coastal states in the United States and from other countries, particularly the Netherlands and countries bordering on the Mediterranean, the authors have found that salt water intrusion is the cause of great concern to many countries and public agencies.

Historical Background

Sea water intrusion and its degradation of well supplies have been studied during the past 30 years in California. In December 1950 the California Division of Water Resources reported (*1*) that 20 out of a total of 35 important coastal ground water basins were suffering serious salt water intrusion or were in immediate danger from it and that the other fifteen were potentially subject to degradation.

The West Coast Basin in Los Angeles County, extending from the ocean about 6–8 miles inland to the Inglewood Fault and about 11 miles along the coast from the Palos Verdes Hills to Ballona Creek, was described (*1*) as the most seriously affected basin. Consequently, it was selected as the site for an experimental creation of a fresh-water barrier (Fig. 1). Probably, the most complete information available on serious sea water intrusion has been compiled for this area by private and public engineering agencies. The possibility of critical ground water depletion or sea water intrusion in the West Coast Basin was predicted by the US Geological Survey as early as 1905. The Los Angeles County Flood Control Dist., which has been sampling ground water in the West Coast Basin for about 25 years, initially noted the com-

mencement of intrusion and brought this occurrence to the attention of local water-producing agencies. By 1931 the mineral constituents of the ground water 2,000 ft inland at Manhattan Beach were too great for potability. After local interests retained consultants to study the situation, reports were rendered outlining the problems and making certain recommendations (*2*). In 1943 a comprehensive, co-

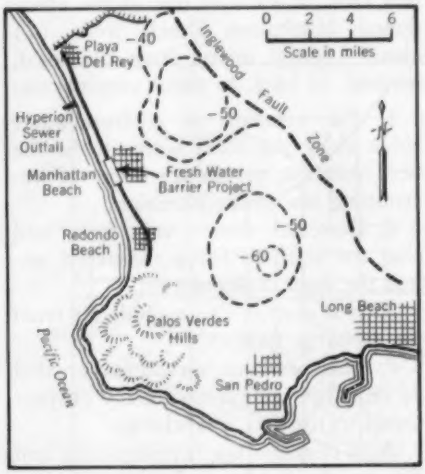

Fig. 1. Fresh Water Barrier Project

The West Coast Basin lies between the ocean and the Inglewood Fault.

operative ground water investigation of the critical situation in the West Coast Basin was undertaken by the US Geological Survey and the Los Angeles County Flood Control Dist. As a result of the detailed report of 1948 (*3*) and others that preceded it, local water-producing agencies and residents were alerted to the excessive overdraft occurring in their basin, which was the only available source of supply at that time. The excessive use of ground water was the result of a tremendously rapid industrial and residential growth. Since the annexations of this area to the Metropolitan Water Dist., beginning in 1948, nearly the entire region overlying the ground water basin receives some supplemental water from the Colorado River. Because this additional water is insufficient to provide a complete supply, further demands must be met from the basin. Adjudication procedures were recently initiated to restrict pumping, and a stipulation has been signed by approximately 90 per cent of the water-producing agencies in the area to provide such limitation voluntarily. Although these actions represent an improvement, they are still inadequate to provide for the recovery of the basin or even to place it in balance. Unless some preventive action is taken, salt water intrusion will continue, eventually destroying the usefulness of the entire basin.

Possible Controls

The report on the cooperative investigation suggested these physical possibilities for the local control of saline water:

1. The construction of artificial subsurface dikes or cutoff walls
2. The development, by pumping, of a water level trough coastward from the saline front
3. The maintenance of fresh-water head above sea level at, and immediately inland from, the saline front.

Only the maintenance of fresh-water head is considered economically feasible. The fresh-water head of 3–13 ft above sea level required along the west coast could be attained only by arti-

ficial recharge through wells, trenches, or pits.

Later, the California report (*1*) discussed these possible methods of restraining sea water intrusion:

1. Raising of ground water levels to or above sea level by reduction or rearrangement, or both, of the pattern of pumping draft
2. Direct recharge of overdrawn aquifers to maintain ground water levels at or above sea level
3. Maintenance of a fresh-water ridge above sea level along the coast
4. Development of a pumping trough adjacent to the coast
5. Construction of artificial subsurface dikes.

The California report also stated:

> Cost is an important factor which must be considered in the selection of proper method of control.
>
> The first method [see No. 1 above] of control, while not necessarily the most desirable, would always be effective in the coastal ground water basins. A detailed and extensive engineering investigation would be required in order to establish salient hydrologic and geologic features necessary for the determination of a long-term, basin-wide balance of draft and replenishment and program of pumping draft reduction or relocation. The other methods would require additional detailed investigation and experimentation in order to determine their feasibility as sound engineering and economic methods of restraint of sea water intrusion. It is probable that the solution for restraint of sea water intrusion in a particular ground water basin might utilize one or more of these latter methods in conjunction with raising of ground water levels to or above sea level by reduction or relocation of pumping draft.

Most Promising Method

Experience of the Los Angeles Flood Control Dist. indicated that the maintenance of a fresh-water head above sea level was the most promising of the suggested solutions. Previous studies had showed that a fresh-water head could be obtained through the use of spreading basins or gravel-packed seepage pits in unconfined aquifers and that recharge through wells would create such heads in confined aquifers. Consequently, an experimental well recharge test was conducted by the Los Angeles Flood Control Dist. in 1950 at one of the abandoned Manhattan Beach wells (*4*) about 4,000 ft inland from the coast, leading, in part, to these conclusions:

1. The creation of a fresh-water ridge along the coast seems to be the best solution to the problem of restraining sea water intrusion.
2. Bacterial slimes will form and clog the aquifers being recharged unless the flow is disinfected.
3. It is desirable to exclude air from the recharge flow.
4. The pressure elevations created by recharge are approximately proportional to the rate of recharge.

As a result of the investigations and reports, the California Legislature provided $750,000 to be used for investigation and study, with the objective of formulating plans and design criteria for the correction or prevention of damage to the underground water of the state by sea water intrusion. Planning and allocation of these funds were assigned to the State Water Resources Board, which, on Oct. 1, 1951, entered into a contract with the Los Angeles County Flood Control Dist. for the installation and operation of the experimental recharge test at Manhattan Beach and Hermosa Beach in the West Coast Basin. Over $642,000 was allocated for this project. The

remaining money was divided among the University of California at Berkeley, the University of California at Los Angeles, and the US Geological Survey for model tests and permeability determinations, chemical quality determinations relative to base-exchange problems, and other factors pertaining to the problem of recharging a pressure aquifer by the injection of fresh water through wells to replace intruding sea water.

trusion as related to rate of injection, thickness, and permeability of the aquifer and the preexisting hydraulic gradient

3. Required spacing of injection wells in relation to thickness and permeability of the aquifer and the preexisting hydraulic gradient

4. Rates and amount of displacement of saline waters and their degree of dilution

5. Degree of chlorination or other

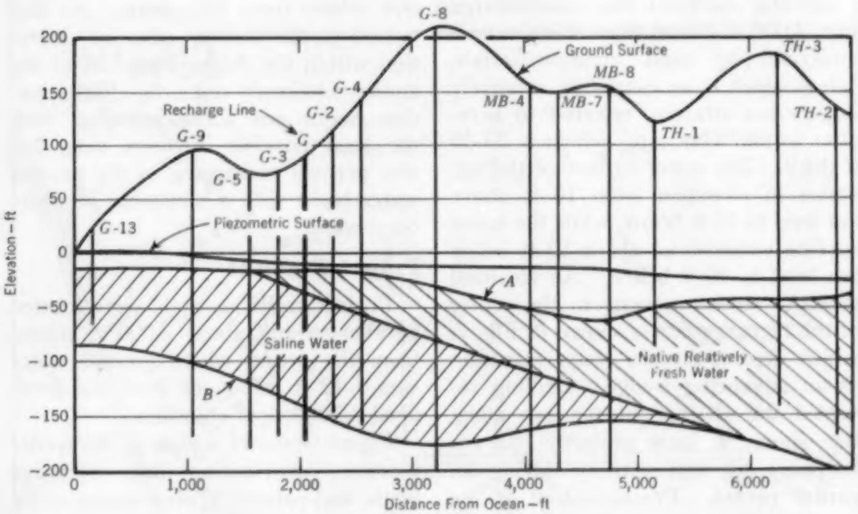

Fig. 2. Extent of Saline Intrusion Normal to Recharge Line

A—*upper boundary of aquifer;* B—*approximate lower boundary of aquifer. The conditions depicted were in existence prior to recharge. The vertical lines designated by letters and numbers, such as "G-13," refer to the locations of various wells, the placements of which are shown in Fig. 3.*

In general, the contract provided for ascertaining these factors:

1. Feasible rates of injection through wells, in relation to the thickness, permeability, and other properties of the aquifer

2. Height and shape of the pressure mound needed to control sea water intreatment necessary to maintain injection capacity of the recharge well and the effect of such treatment on the growth and formation of microorganisms within the aquifer body

6. Type of construction of wells and maintenance problems connected with continued injection, including such

procedures as bailing, surging, shock chlorination, dry-ice treatment, and aeration

7. Studies of the base-exchange reaction within, and its effect on the permeability of, the aquifer.

Geology and Barrier Theory

Preliminary geologic exploration and theoretical considerations involved in creating a pressure mound within a pressure aquifer were published in 1953 (*5*).

Drilling disclosed that the recharge site, 2,000 ft inland from the ocean, is underlain by sand dune materials, below which is an extensive, relatively impervious stratum, referred to hereafter as the "clay cap," which is 20–30 ft thick. The upper surface of the cap varies in elevation from 10 ft above sea level to 10 ft below, while the lower surface varies from about 10 ft below sea level to 40 ft below. An idealized geologic section normal to the center of the recharge line is shown in Fig. 2, which depicts the sea water intrusion as an advancing wedge. Drilling revealed the absence of the cap along the shore, a lack probably due to stripping by surf activity during an earlier period. Pressurization of the aquifer may be assumed as being complete, however, from at least 1,500 ft oceanward of the recharge line to, probably, several miles inland.

The aquifer underlying the clay cap consists of an upper, brown, phase; an intermediate, gray, phase; and a lower, blue-gray, phase. At the recharge line these sections are all in hydraulic continuity and represent a merging of important inland water-bearing aquifers, which range in depth from 100 ft to several hundred feet below the ground surface, but which join to form a single aquifer about 100 ft thick near the coast. In general, the aquifer consists of yellowish-brown sands, silts, and limited gravel stringers with occasional clay bands. The intermediate gray phase contains the larger consistent gravel stringers, and it grades with depth progressively into the lower phase, which contains an increasing amount of very fine silty sands and clay bands. The aquifer is underlain by a relatively impervious bottom consisting of blue silts and clay. The thickness of the aquifer generally increases with distance downcoast (southerly) and inland from the ocean. As discussed subsequently, effective injection within the thinnest portion of the aquifer obviously not only checks further major sea water intrusion with the least possible injection rate, but also permits recharging of the ground water basin with a minimum of waste oceanward.

Project Facilities

Project recharge wells were located parallel to and about 2,000 ft inland from the ocean, where ground water was 6–12 ft below sea level and averaged 16,000 ppm chlorides.

Figure 3 shows a plan of the feeder pipeline, distribution line, recharge wells, and pattern of observation wells. The Colorado River water used for injection was obtained from a distribution feeder of the Metropolitan Water Dist. This pipeline includes about 7,000 ft of 20-in., 12 gage–welded steel pipe laid in public streets. The distribution line, consisting of about 4,300 ft of welded-steel line, 20, 16, and 14 in. in diameter, was located in a railroad right-of-way, thereby minimizing the difficulties of acquiring a right-of-way. Recharge wells were spaced at intervals of 1,000 ft along this path. Intermediate observation wells were designed also to be used as recharge wells so that spacing could

be reduced to 500 ft, if that was found desirable. Initially, 36 observation wells 8 in. in diameter were drilled; then, during recharge operations, 4-in. and 2-in. observation wells were put down as required. Hence, observations were finally taken in about 58 project wells, as well as in wells inland from the recharge line.

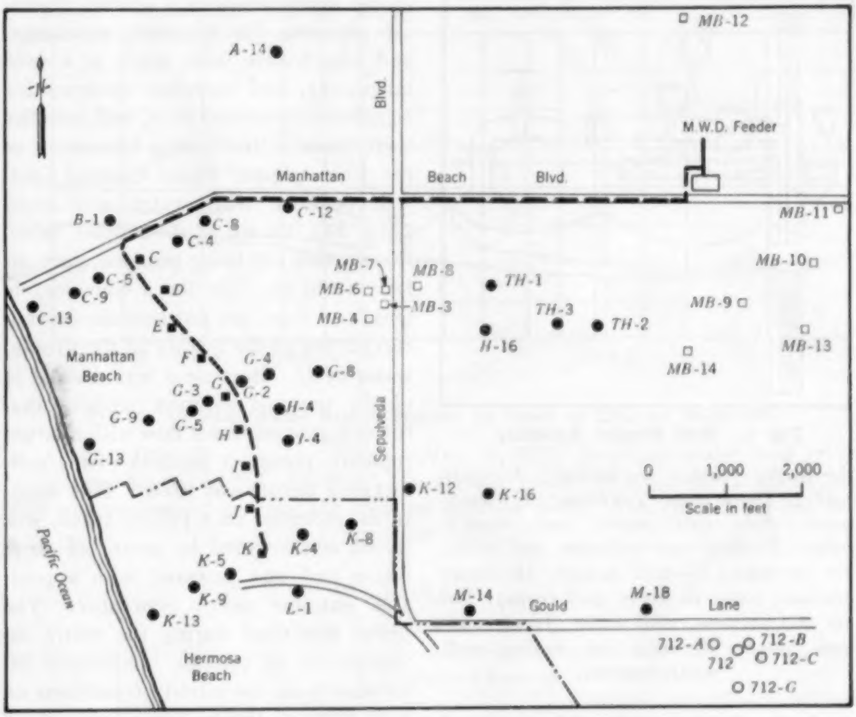

Fig. 3. Recharge Project Wells and Supply Line

Key: ■—project recharge wells; ●—project observation wells; □—Manhattan Beach wells; ○—California Water Service Co. wells; the broken line indicates the supply line. (M.W.D. denotes "Metropolitan Water District.")

Development Methods

The recharge wells, drilled by cable tool methods, had 12-in. perforated casings. Well *E* was gravel packed and consisted of a 20-in. conductor, which was sealed with cement grout at the clay cap; the well was then carried to full depth by cable tool, with a 12-in. casing and an 18-in. diameter gravel shoe. In later testing, a similarly gravel-packed well (*I-A*) was drilled (utilizing rotary methods) to replace one of the nongravel-packed wells. The original 36 observation wells were drilled with cable tools, and 8-in. casings were used. Later, rotary drills and 4-in. casings were employed. Well development was accomplished

by standard surging and bailing procedures. Recharge wells were further developed by 16–18 hr of pumping, which was followed by transmissibility * tests and permeability computations according to the analysis and

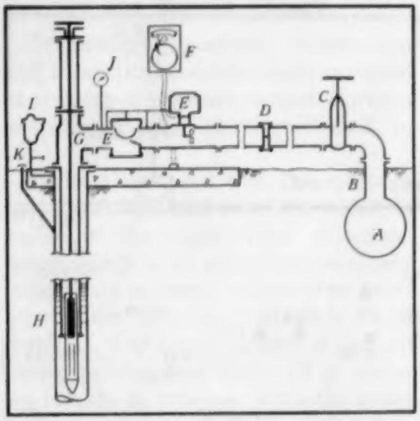

Fig. 4. Well Header Assembly

A—*feeder line;* B—*lateral;* C—*gate valve;* D—*dresser coupling;* E—*automatic flow rate meter and control valve;* F—*flow rate indicator and totalizer recorder;* G—*well header;* H—*back-pressure valve in lower well casing;* I—*air and vacuum relief valve;* J—*air vacuum gage;* K—*inlet for taking well measurements.*

methods developed by Cooper and Jacob (*6*). All well perforations, located in accordance with detailed geologic logs kept during drilling, were placed in only those areas where there were sufficient gravels to form proper filters. Extensive formation samples, including frequent log and drive core specimens, taken during drilling in selected zones were forwarded to the Los Angeles Flood Control Dist. laboratory and the California Division of Water Resources for screen analyses and permeability determinations. Comprehensive ground water samples were also taken during drilling for complete chemical analyses, as well as bacteriologic determinations. Partial chemical analyses for chloride, carbonate, and bicarbonate were made at a field laboratory, and complete analyses for significant constituents of well samples were made at the testing laboratory of the Los Angeles Flood Control Dist.

Experience with water well sampling has shown that samples taken from a well not being pumped, particularly from one idle for a considerable length of time, are not necessarily representative of the quality of the ground water body. Because it was desired to obtain pumped samples without disturbing ground water flow with a large-capacity pump, a portable 4-in. submersible pump was used. This apparatus, mounted on a pickup truck, was raised and lowered by means of an A frame and was powered with a portable gasoline motor generator. The pump was used during the entire investigation to provide continuous information on the salinity conditions on both sides of the recharge line. Such samples were augmented by conductivity traverses to give detailed information on the salinity gradation of the aquifer with depth during both pumping and static conditions. The interface between fresh and salt water could often be identified by means of this technique.

An integral part of the project facilities was a high-rate automatic-control chlorinator, capable of delivering 50–2,500 lb chlorine per 24 hr and an au-

* The rate at which percolating waters pass through a unit width of a given aquifer under a unit hydraulic gradient.

tomatic residual chlorine recorder. Additional equipment at each recharge well header assembly (see Fig. 4) included a gate valve, a flow rate control valve, a standard propeller type meter, operated from the ground surface) at the terminus of the conductor pipe below ground water level. Pressure gages and pressure vacuum release valves were also included.

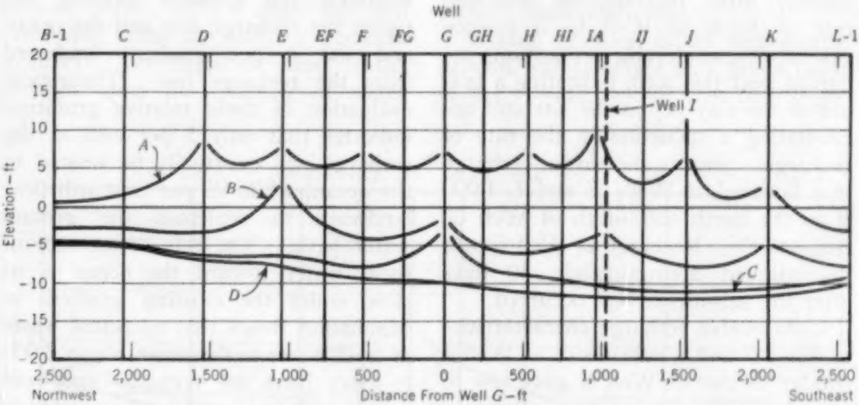

Fig. 5. Ground Water Profile Parallel to Coast at Line of Recharge

A—*Sep. 16, 1954;* B—*Jun. 15, 1953;* C—*Mar. 10, 1953;* D—*Static water level prior to recharge beginning Feb. 12, 1953. An average mound of about 4–8 ft above sea level was maintained between the terminal injection wells. See Table 1 for the in-injection rates.*

TABLE 1

Recharge Injection Rates (See Fig. 5)

Date	Injection Rates—*cfs*									
	Wells									Total
	C	*D*	*E*	*F*	*G*	*H*	*I-A*	*J*	*K*	
2/12/53	0	0	0	0	0	0	0*	0	0	0
3/10/53	0	0	0	0	0.75	0	0*	0	0	0.75
6/15/53	0	0	1.05	0	0.54	0	0.36*	0	0.48	2.43
9/16/54	0	0.37	0.50	0.56	0.64	0.72	1.11	0.70	0.36	4.96

* Well *I*

a totalizing and instantaneous flow-registering recorder, a 6-in. conductor pipe within the well casing, and a back-pressure valve (which could be

Recharge Operations

Recharge was initially commenced at Well *G* at a rate of 0.5 cfs. Subsequent increases in flow were made

after intervals of operation of approximately 1 week each. The rate of movement of the fresh water to the nearest observation wells was closely timed by means of pumped-water samples and conductivity traverses. Shortly after reaching an injection rate of 1 cfs at Well *G*, a surface cave-in of considerable proportions occurred near this well, indicating a failure of the clay cap at the site and necessitating a reduction in the rate of recharge. Shortly thereafter, recharge was initiated at Wells *E* and *I*, 1,000 ft to the north and south of Well *G*, respectively. Recharge at Well *G* was discontinued approximately 30 days after the subsidence had occurred.

Unfavorable recharge characteristics at Well *C* and a subsidence at Well *I* similar to that at Well *G* gave rise to plans to utilize the existing intermediate recharge Wells *D, F, H*, and *J*, thereby decreasing well spacing to 500 ft and, consequently, reducing at each well the flow required to build up the pressure mound. Later, Well *I* was replaced with a gravel-packed well (*I-A*), about 60 ft north of Well *I*. In November 1953 injection was being maintained at 8 wells (*D, E, F, G, H, I-A, J*, and *K*), and a continuous fresh-water barrier above sea level existed for approximately the 4,000 ft affected by these wells. A profile of pressure gradients along the recharge line, as presented in Fig. 5, shows that the injection resulted in the successful maintenance of a fresh-water barrier. It may be noted (Table 1) that with the total combined injection rate of 4.96 cfs at 8 wells, an average mound of approximately 4–8 ft above sea level was being sustained between the terminal injection wells. Figure 5 also demonstrates that there is a cumulative effect of recharge through adjacent wells in the development of a pressure barrier.

Figure 6, presenting a profile of pressure gradients normal to the center of the recharge line, shows both the relatively flat gradient existing between the recharge line and the ocean and the steeper gradient landward from the recharge line. Theoretical evaluation of these relative gradients indicates that only 5 per cent of the recharge will eventually be wasted to the ocean, while 95 per cent will flow landward to replenish the ground water basin. The rate of advance of fresh water toward the ocean is so slow under the existing gradient in Manhattan Beach that no actual waste of fresh water to the ocean, about 2,000 ft away from the recharge line, will occur within 10 years of continuous recharge.

Recharge Well Acceptance Rate

The recharge well acceptance rate, or rate at which the well will accept flow, is a fundamental factor in determining well spacing, as well as in establishing the economics of building and maintaining a barrier mound. The acceptance rate of a recharge well depends upon the type and size of well, in relation to the characteristics of the aquifer; the amount of free chlorine available in the recharge water to prevent bacterial slime formation; and the degree and type of redevelopment utilized when the acceptance rate falls too low.

It is necessary to define certain terminology in order to clarify a basic concept that has been established in the recharge test. Injection head, as used in this paper, is the pressure required in a recharge well to cause the

injected water to pass through the well perforations into the face of the aquifer. This factor is the difference, at a given time, between the water surface elevation in the recharge well casing and the maximum piezometric ground water surface near the well (resulting from the existing pressure mound). The injection head is dependent upon the quantity of water in the aquifer immediately adjacent to the well. Because normal pressure mound elevations are attained when the flow becomes laminar, the advantage of a large-diameter or a gravel-packed well to reduce the required injection head is obvious.

Mound elevation is the piezometric ground water surface at a given point of the mound, whose size and shape

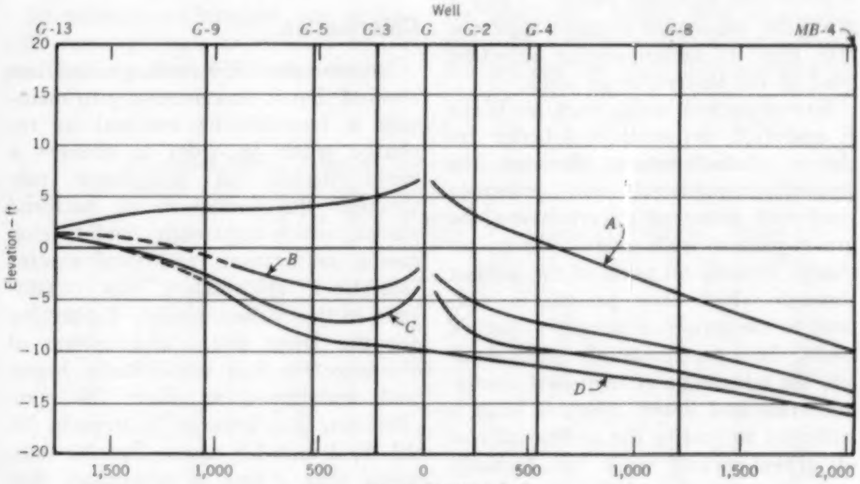

Fig. 6. Ground Water Profile Normal to Line of Recharge Through Well *G*

A—*Sep. 16, 1953;* B—*Jun. 15, 1953;* C—*Mar. 10, 1953;* D—*Static water level prior to recharge beginning Feb. 12, 1953. Theoretical evaluation of these gradients indicates that only 5 per cent of the recharge will eventually be wasted to the ocean, located about 2,000 ft to the west of Well* G.

being injected, the type and size of recharge wells, the number of casing perforations, and the local transmissibility characteristics of the aquifer in the immediate vicinity of the recharge well. Although this head is independent of the height or shape of the pressure mound, it is assumed that the head is influenced by the turbulence of flow through the perforations and are dependent upon the amount of water being injected in a given reach, the spacing of the recharge wells, the transmissibility of the aquifer, and the natural ground water gradients as unaffected by recharge.

Injection rates used in the test varied widely during different portions of the investigation. A maximum rate of 1.86 cfs was obtained in gravel-

packed Well *E* for a few hours. Rates at Wells *E* and *I-A* over a long period of time indicated the ease with which the acceptance rate can be maintained in gravel-packed wells. The maximum sustained average rate at well *E* was 1.06 cfs, with a 53-ft head, and at Well *I-A*, this rate was 0.74 cfs, with a 20-ft head. Average injection rates at the nongravel-packed wells were maintained with somewhat greater relative unit injection heads. Table 2 gives the maximum average injection rate and its accompanying injection head at the test recharge wells.

Gravel-packed wells, such as Wells *E* and *I-A*, definitely had better recharge characteristics. Because the aquifer encountered was primarily sand with scattered gravel layers, the gravel-packed wells were able to recharge directly all parts of the aquifer through which they passed, in contrast to the action of nongravel-packed wells. In a predominantly sandy aquifer, the advantage of increased acceptance rate and lower injection head is sufficient to justify the additional cost of gravel-packed wells for recharge purposes, even though the cost of such wells may be as much as twice that of standard wells. In a coarse-gravel aquifer, recharge could probably occur through a nongravel-packed well without excessive injection head requirements.

Specific studies of the optimum well size were not made because it was felt that the success of the overall program might be jeopardized by the possibility of drilling too small a well for the recharge line. From experience gained in the 1950 recharge well test and from the two principal types of wells in the recharge line, it is felt that the best well for recharge purposes, in relation to the aquifer material at the test site, is one with a relatively large gravel-packed envelope and a relatively small casing. Consideration of the economic factors and the necessity for providing sufficient work space for well tools, sample pumping equipment, conductor pipes, and valves within the casing indicates that a 24-in. gravel-packed well with a 12-in. casing may prove best for recharging.

Chlorination

Because the 1950 recharge well test showed that it was necessary to maintain a free-chlorine residual in recharge water in order to prevent a rapid decline of acceptance rate through the formation of bacterial slimes, which apparently tend to clog casing perforations and local aquifer interstices, chlorination was considered in the earliest phases of planning for the latest test. Chlorination of the injection flow was initially begun and maintained at about 20 ppm. This rate was lowered by steps to 15, 12, 5, 3 and 1.5 ppm. Results indicated that a loss of acceptance rate began occurring at 1.5 and 3 ppm, and there was considerable evidence that even 5 ppm was not sufficient to maintain control of the slime-forming bacteria. Chlorination has been maintained at 8 ppm for several months, with the exception of short periods of heavy chlorination (15–20 ppm) to test the effectiveness of the treatment. Results indicate that 5–8 ppm are required to maintain acceptance rate of recharge wells in sediments similar to those at Manhattan Beach. Although large doses of chlorine (15–20 ppm) maintained for several days have resulted in slight improvement of acceptance rates in some wells, no definite

conclusions about the benefits of this procedure can be drawn.

Some degree of increase in well acceptance was noted following shutdown for well repairs, but this may have resulted from the release of progressive air binding and a mild surging which may have been caused by closure and subsequent reactivation of the recharge wells.

Mound Characteristics

In order to understand how a specific recharge well is affected by its position in a line of recharge wells, it is necessary to follow the physical transition which occurs between the beginning of injection and the creation of a stable pressure mound. Such a description showing the changing conditions will be presented in this paper as if there were a time lag between occurrences, although in a true pressure aquifer there is none, because pressure changes, theoretically, are transferred instantaneously. Practically all pressure aquifers, however, have a storage factor, which has been variously attributed to compressibility of the aquifer materials or the confining strata, or both. Actually, no pressure aquifer is perfect, in that leakage to a greater or lesser degree occurs through the confining strata or ground water moves to adjacent or contiguous free zones.

All the flow from a recharge well is radial, except when the recharge cone of a single well is superimposed upon an existing ground water slope. Under such conditions, the larger portion of the injected water flows along the gradient. Radial flow emanating from the well continues along streamline trajectories until it is affected by the flow of adjacent wells at a point about midway between wells.

As the area of pressure caused by recharge continues to expand toward a condition of stability, the pressure at a given point is the resultant of the effect of each well. The integrating effect of merging recharge flows forms a continuous mound, a condition characterized by the establishment of a two-dimensional flow (no lateral movement of recharge water) within a short distance from the line of recharge.

Observations of the actual buildup of the mound during the initial period

TABLE 2

Maximum Average Injection Rate and Accompanying Injection Head

Well	Date	Max. Avg. Injection Rate *cfs*	Water Surface Elevation in Recharge Well *ft*	Estimated Mound Elevation *ft*	Indicated Injection Head *ft*	Indicated Unit Injection Head *ft/cfs*
D	10/22/53	0.48	55	14	41	85
E	8/20/53	1.06	67	14	53	50
F	2/18/54	0.61	48	9	39	64
G	10/22/53	1.03	69	12	57	55
H	8/20/53	1.01	68	10	58	57
I	5/14/53	0.50	70	− 2	72	144
I-A	2/25/54	0.74	30	10	20	27
J	11/26/53	0.70	67	11	56	80
K	12/17/53	0.74	54	5	49	66

of recharge (Fig. 5) indicated a considerable lag in the development of a stable pressure gradient to the ocean side of the recharge line. About 2 months of recharge operations were necessary before the ground water elevation on the ocean side rose above sea level, with about 6 months of recharge being required to develop a relatively stable gradient. This delay was the result of either a continued bypassing

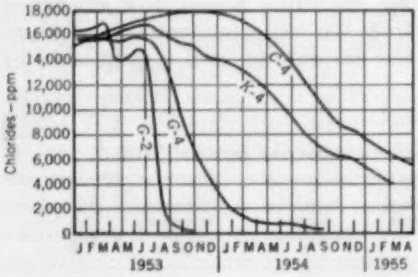

Fig. 7. Chloride Concentration in Project Wells

Distances measured inland from recharge line: G-2, *240 ft;* G-4, *520 ft;* K-4, *470 ft; and* C-4, *580 ft. Values below 250 ppm were not plotted. See Fig. 8 for additional data.*

of flow through the internodal pressure vallleys (low points of the pressure ridges midway between points of fixed pressure, or nodes, at the recharge well) prior to the development of the entire barrier to sea level or the storage effect within the oceanward aquifer or both of these causes. Well logs indicate that the confining clay membrane oceanward of the recharge line is not continuous and will permit ground water storage.

Because the recharge rates and the interval of time between the initiation of recharge at the individual wells varied, it is not possible to evaluate accurately the time required to establish a stable landward gradient. When recharge was commenced at a single well (*G*), however, pressure effects were directly noted 1,180 ft landward and, under a constant recharge rate, a condition of stability was attained in approximately 5 days.

Inspection of the piezometric gradient curve indicates that the individual cones around each recharge well merged into a relatively uniform barrier within 250–500 ft of the recharge line, both landward and oceanward. This occurrence is shown in Fig. 6 by the relatively uniform ground water gradient between Wells *G-4* and *MB-4* and between Wells *G-5* and *G-13*.

After the oceanward pressure lag had been overcome, there was no difficulty in sustaining the desired mound elevations through maintenance of a constant recharge rate. It is not apparent, however, whether a complete barrier to sea water intrusion has been formed. The most critical location in checking intrusion is assumed to be the point midway (internodal point) between the recharge wells. Because the mound elevation is the least at the internodal point, enough fresh water head must be maintained there to overcome the higher density of sea water in order to prevent intrusion near the bottom of the aquifer. On the basis of an average elevation of the bottom of the aquifer of − 110 ft, it is necessary to maintain a fresh water head of approximately 2.7 ft above sea level at the internodal point.

Effects of Injection

Because injection commenced in an aquifer zone that had been degraded

by sea water intrusion to a chloride concentration approximately equal to that of sea water, at first there was apprehension that the operation might cause and push a saline wave of similar concentration inland to fresh water-producing areas about 6,000 ft from the recharge line. Variations in chloride salinity, constituting the basic indicator for tracing ground water movement landward and seaward, as well as along the line of injection wells, were detected by chemical determinations made of ground water samples collected by pumping, use of a "thief sampler," and conductivity traverses made in observation wells.

Salinity–time histories of the wells showed the progressive effect of recharging, as indicated in Fig. 7 and 8. The arrival of fresh water was noted 250 ft inland by a swift increase in chloride concentration followed by a rapid freshening of the aquifer. The freshening 500 ft inland was preceded by a relatively lesser increase in chloride concentration. At 1,000 ft inland, freshening occurred without a distinguishable rise of salinity. The interface between waters of different salt concentrations within the merged aquifer was readily identified at a given well by means of conductivity traverses, when the interface fell within the limits of well perforations. The traverses indicated that fresh water seemed to arrive as an overriding wedge, which slowly displaced the dense, saline water. A study of repeated traverses taken at more than 50 observation wells led to these conclusions:

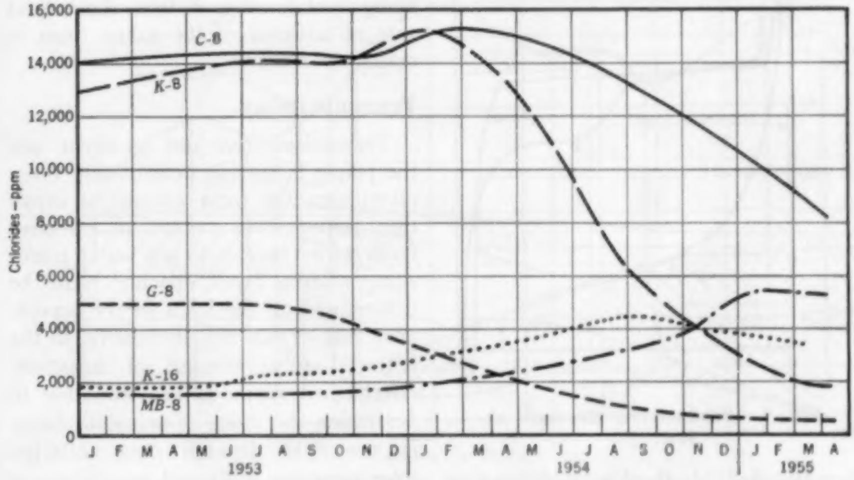

Fig. 8. Chloride Concentration in Project Wells

Distances measure inland from recharge line: C-8, *940 ft;* K-8, *930 ft;* G-8, *1,160 ft;* K-16, *3,000 ft; and* MB-8, *2,850 ft. Fig. 7 presents data from other wells.*

1. Historically, a zone of mixed waters had developed as a result of

alternate periods of landward flow of sea water and oceanward flow of fresh water, occurrences which, in previous years, probably took place seasonally and resulted in increased diffusion or mixing of the two bodies of water.

2. The gradients that existed prior to and during recharge permitted undiluted sea water to intrude as a wedge beneath the mixed waters.

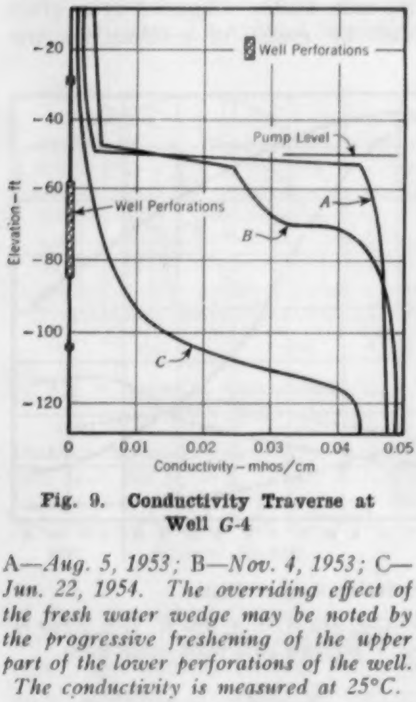

Fig. 9. Conductivity Traverse at Well *G*-4

A—*Aug. 5, 1953;* B—*Nov. 4, 1953;* C—*Jun. 22, 1954. The overriding effect of the fresh water wedge may be noted by the progressive freshening of the upper part of the lower perforations of the well. The conductivity is measured at 25°C.*

3. During injection, the imported, lighter fresh water moved inland as a wedge overriding the underlying intruded saline or native mixed ground water bodies.

The creation of the overriding fresh water wedge within the merged aquifer may be noted on Fig. 9 by the progressive freshening of the upper part of the lower perforations of Well *G-4*, located 500 ft landward of Well *G*. The location of the interfaces between native waters, intruding sea water, and injected fresh water is shown, somewhat ideally, in Fig. 10.

The recharge test has established the feasibility of reclaiming an aquifer which sea water has already polluted. Comparative isochlors prior to and following recharge are given in Fig. 11, which shows that the basin area is being reclaimed and that the inland rate of advance of the saline front is relatively minor.

Transmissibility

Transmissibility and gradient are the prime factors in determining for a given area the total amount of injection required to create an effective fresh water barrier to sea water intrusion, whereas well spacing must be determined on the basis of the acceptance rate of the well in relation to the required total amount of injection. Established methods are available to determine the value of transmissibility in the field through data collected from pumping wells and nearby observation wells.

If very little change occurs in the values of drawdown over a period of time, with a constant rate of discharge in both pumping and observation wells, conditions are said to be at equilibrium. Nonequilibrium conditions exist where drawdown is measurably increasing in relation to time. The characteristics of the aquifer at the test site, the rate of pumping, and the limited time of pumping at the test wells precluded the use of equilibrium formulas for the pumping-test data. Nonequilibrium equations, however, were quite suitable.

The use of transmissibility values determined in field tests as averages representing the entire aquifer is limited in accuracy by the effects of the natural variations which exist in the aquifer materials. Localized areas of high or low transmissibility in the vicinity of the pumping well and, to some extent, near the observation wells can greatly influence the data. The transmissibility value chosen, during recharge varied from 0.17 to 0.18 cfs per foot.

Spacing of Recharge Wells

After establishment of the recharge mound, there are two very important considerations (assuming a uniform, homogeneous, completely confined aquifer) involved in a line of recharge wells which are creating a complete, stable barrier to sea water intrusion:

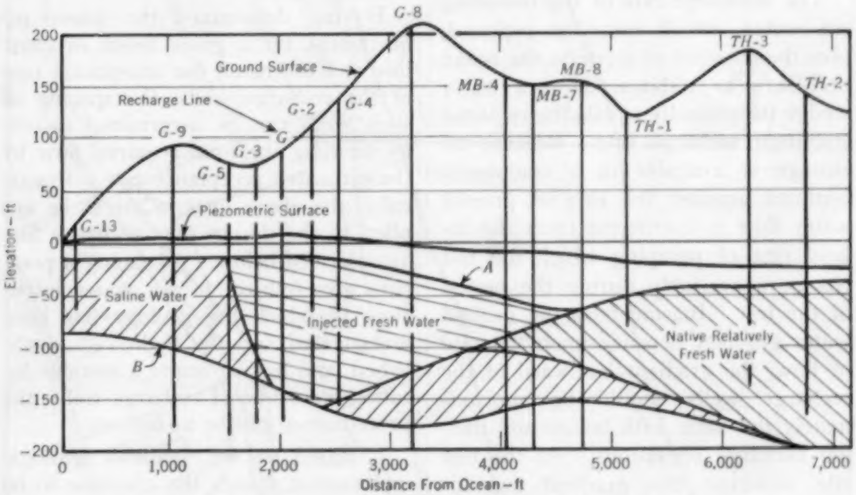

Fig. 10. Injected Fresh-Water Wedge Normal to Recharge Line

A—*upper boundary of aquifer;* B—*approximate lower boundary of aquifer. This idealized section shows the interfaces between native waters, intruding sea water, and injected fresh water 2 years after recharge was begun. See Fig. 2 for the extent of saline intrusion before recharge.*

therefore, should be an average of several such values taken from the pumping and observation wells.

The transmissibility ascertained from the pumping tests gave good correlation with the values computed from recharge gradients. Average transmissibility during pumping ranged from 0.12 to 0.19 cfs per foot of width of aquifer, whereas subsequent determinations based on measured gradients

1. The rate of fresh-water recharge in a given section parallel to the coastline must be sufficient to replace the previous intruding flow of sea water.
2. There must be some movement of fresh water toward the ocean to stabilize an intruding sea water wedge oceanward of the recharge line.

A seaward flow occurs because a fresh-water head above sea level is required at the recharge line to balance

the pressure of the denser sea water in the lowermost part of the aquifer. With elevations above sea level at the recharge line, there will be an oceanward gradient, resulting in a freshwater flow toward the ocean. The test has established, however, that the seaward flow of fresh water is of no practical or economic significance because it is minor and relatively slow under the test site gradients.

The discharge rate of the intruding sea water, which must be replaced, plus the quantity of waste to the ocean necessary to stabilize the sea water wedge theoretically equals the required stabilized recharge rate. Because no storage is available in a completely confined aquifer, the rate of ground water flow is contingent upon the inland rate of pumping which did not change appreciably during the period of the test. Inasmuch as the ground water gradient depends upon the rate of flow, the gradient landward of the recharge wells should be approximately the same both before and during recharge operations. At the test site, however, this gradient was increased about 58 per cent by recharge, indicating that the required recharge rate was greater than the prior rate of sea water intrusion. One or more of the following factors is responsible for the change of gradient and the corresponding indicated increase of flow landward:

1. Significant storage exists within the local aquifer or in some portion of the aquifer contiguous to that being recharged, or in both.

2. A significant quantity of leakage is occurring upward through the confining layers inland from the recharge line.

3. Lateral flow of the injected water is so great that a partial barrier extends over an area much larger than is indicated, as yet, by the arrival of injected fresh water. It is conceivable that a complete barrier can be formed within the reach of recharge wells and that a partial barrier can be formed off the ends of the recharge line, the degree of effectiveness decreasing with the lateral distance from the outermost recharge wells.

Having determined the water requirement for a given reach of coast line and estimated the acceptance rate of the recharge wells, the spacing of such wells can be ascertained merely by dividing the total required flow by the estimated acceptance rate. Practically, the above criteria might be applied to the design of a recharge line as described below. Assuming a pressure area subject to sea water intrusion, in which the geology has been investigated and the hydrology established, and having found a suitable location for a line of recharge wells, the procedure would be as follows:

1. Based on the available geologic information, divide the coastline to be protected into reaches of estimated uniform transmissibility.

2. Drill a test hole near the center of each reach throughout the entire depth of aquifer materials to define the geology more definitely and to establish the depth of recharge well required. This test hole could be used later as an observation well.

3. Based on the established stratigraphy, the apparent permissible injection head, and the estimated transmissibility of the aquifer, a recharge well would be designed and constructed at or near this location.

4. A pumping test would be performed utilizing the recharge well and

available observation wells to establish more accurately the aquifer's transmissibility. Such a test should be made with moderate rates of pumping to prevent overdevelopment of the well. a further check on the geology. This would be followed by the drilling of the adjacent recharge wells at each side, and the above check of geology and transmissibility would be dupli-

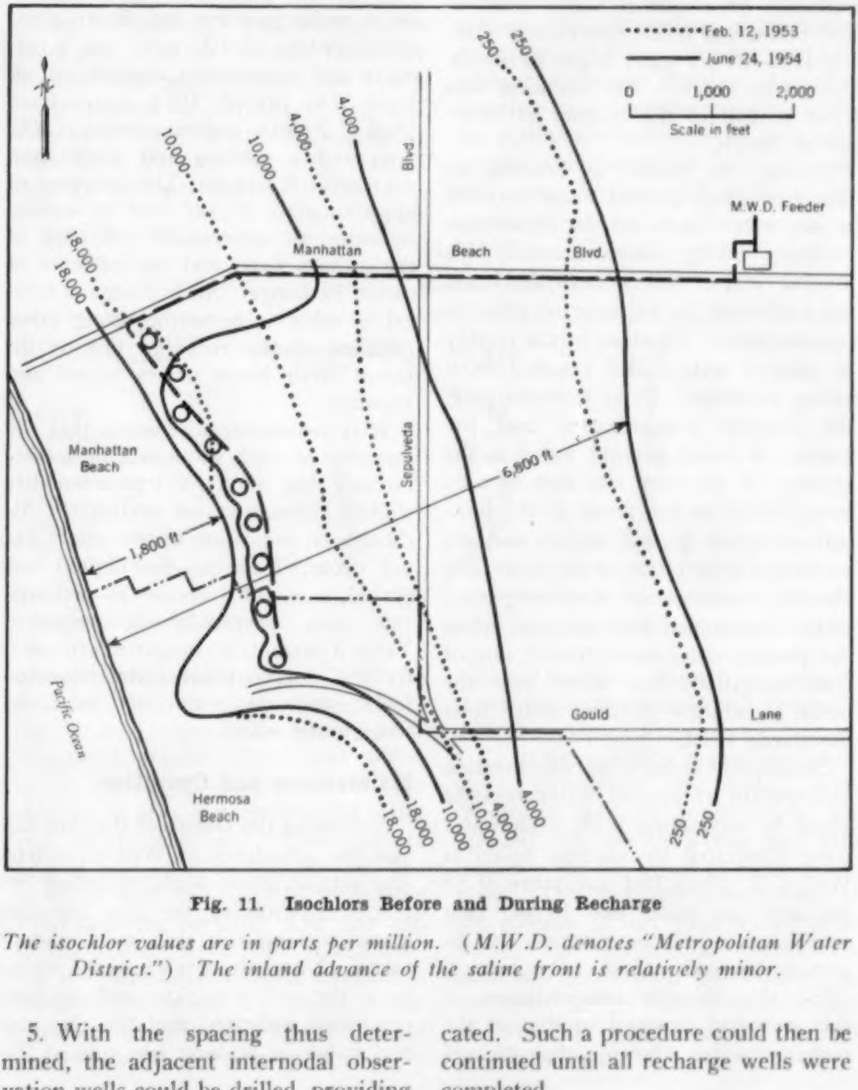

Fig. 11. Isochlors Before and During Recharge

The isochlor values are in parts per million. (M.W.D. denotes "Metropolitan Water District.") The inland advance of the saline front is relatively minor.

5. With the spacing thus determined, the adjacent internodal observation wells could be drilled, providing cated. Such a procedure could then be continued until all recharge wells were completed.

Water Quality

In the stretch of coastline from Playa del Rey to Palos Verdes Hills, as of 1903–04, natural fresh ground water of the Merged Silverado Zone was escaping to the ocean. With the extensive drawdown of water levels to and below sea level, particularly during 1931–46 sea water began to invade this entire reach. The intrusion was most critical in the vicinity of Manhattan Beach.

During the period of reversal of flow from fresh ground water seaward to sea water landward, an occurrence probably taking place seasonally for several years, waters near the coast were affected by increase in chloride concentration. Changes in the quality of ground waters also resulted from cation exchange. Prior to recharging, the chloride concentration and the quality of native ground water in the vicinity of the test site had already been altered as the result of the mixture of native ground waters and sea water and their effect on the soil. The chloride concentration of native ground water, determined from analyses when the project wells were drilled, ranged from essentially sea water near the ocean to slightly polluted water near Sepulveda Blvd.

Subsequent changes in concentration and quality of ground water brought about by recharging with fresh water were illustrated by samples taken at Well *G*-2, which had a mixture of 85 per cent sea water and 15 per cent original native water, prior to the injection of fresh water. By Jun. 4, 1954, the chloride concentration in this well had dropped to that of the recharge water, showing that the sea water had been completely displaced. In moving from the injection well, *G*, to Well *G*-2, the injected fresh water also underwent cation exchange, a fact that is evident from a comparison of the recharge water and the ground water from Well *G*-2. A typical analysis of recharge water has shown a sodium content of 190 ppm and a calcium and magnesium content of 46 ppm. On Jun. 4, 1954, water from Well *G*-2 had a sodium content of 242 ppm and a calcium and magnesium content of 8.3 ppm. This increase of approximately 27 per cent in sodium indicates an appreciable softening of the ground water and the influence of cation exchange. Such change is typical of what is occurring along other portions of the recharge line as injected fresh water moves inland and seaward.

It is reasonable to assume that the injection of fresh water will ultimately increase the aquifer's transmissibility slightly through cation exchange. Although an indication of this effect has not occurred during the limited test period, a slight increase in recharge rate may eventually be required. Table 3 presents a comparison in quality of Colorado River water imported for injection, sea water, and local, native ground water.

Maintenance and Operation

Following the failure of the clay cap and the subsidence at Well *G*, extensive rehabilitation work, including attempts at grouting the clay cap and gravel-packing the well, were undertaken. Test holes drilled in the vicinity of the well to explore underground conditions indicated that the clay cap had failed on at least one side of the

well and was no longer in place. Conductor pipes were drilled in an attempt to gravel-pack the area, while bailing and surging the well, with little or no success. Extensive grouting procedures were undertaken through newly drilled 2-in. wells and by partially filling the recharge well casing with sand and grouting through holes cut near the clay cap. The well was finally gravel packed through the area of subsidence by surging and bailing materials from the well as they entered through well perforations and adding gravel to the subsidence area until the well was considered stabilized. During the final stages of the process, disintegrated granite (clay) was added to fill the upper hundred feet of the subsidence area and replace the materials at the clay cap. These efforts proved successful, in that the well has operated with no difficulties from June 1953 until the present. The clay cap failure and the experience gained during the rehabilitation work established these considerations for design, development, rehabilitation, operation, and redevelopment of recharge wells:

1. It is apparent that a well drilled in coastal deposits consisting of fine to coarse sands with limited stringers of gravel should be gravel packed in order to replace with gravel the materials removed from the aquifer during development procedures, as well as to prevent the formation of excessive voids and subsequent serious well subsidence problems. Further, it is obvious that in a pressure aquifer, where the confining clay layer is perforated by the well casing an area of weakness may develop and result in excessive leakage. Hence, a properly constructed cement seal will always be desirable in such a zone.

2. In the grouting operations previously mentioned, the major grout movement appeared to be lateral and upward, whereas there was very little tendency for the grout to move downward. This fact was substantiated by the absence of any evidence of grout within the perforations below the grouting zones and, particularly, by the holes drilled during rehabilitation at well *G* which passed through grouted areas.

TABLE 3

Quality of Various Waters

Constituent	Recharge Water* *ppm*	Sea Water *ppm*	Water at Well *G*-2 *ppm*	Native Fresh Water *ppm*
Calcium	35	400	5	58
Magnesium	11	1,400	4	17
Sodium-potassium	190	10,600	242	74
Carbonate	28		16	0
Bicarbonate	106	120	130	284
Sulfate	263	2,650	276	37
Chloride	98	18,760	94	75
Total hardness	139	6,750	27	215

* Softened Colorado River water.

3. Because it is obvious that recharge operations will place the clay cap under additional pressure, particularly at the zone of weakness along the well casing, care should be taken during operations to avoid rapid pressure changes resulting from sudden fluctuations in injection rate. Recharge should be commenced and stopped slowly by means of small steps, allowing sufficient time for pressures to stabilize between such changes. In addition, it is recommended that the water supply to the well distribution line be controlled with a pressure regulator and that changes at individual wells be made with manually controlled valves.

4. In relation to redevelopment of recharge wells, as distinguished from rehabilitation required by the clay cap failure, Well *K* was successfully redeveloped by moderate surging and bailing. Because of aquifer conditions encountered at the test site, pumping was not used as a redevelopment procedure because it would have removed excess quantities of sand, a condition probably conducive to additional failure of the clay cap. In a gravel-packed well, however, pumping could probably be used safely as long as more gravel was added to the gravel envelope to replace the removed aquifer sediments.

Costs of Project

Test costs were carefully analyzed from the viewpoint of establishing a routine barrier project. These costs may be used for estimating expenses only in an area with similar geologic formations, aquifer depth, transmissibility characteristics, and pumping draft conditions. A variation in one of these factors might greatly change the actual costs. An analysis indicated that for conditions at Manhattan Beach the total capital outlay and annual operation and maintenance costs per mile of recharge line would probably be about $186,000 and $32,000, respectively, exclusive of the cost of a recharge water supply.

Considering the cost of a recharge project solely for replenishment to the basin as a source of supply to a West Basin distributing agency, the costs would be as shown in the following table:

Water supply (3650 acre-ft at $20 per acre-foot)	$ 73,000 per mile
Annual cost of retirement (capital outlay)	14,900 per mile
Annual cost of maintenance and operation	32,000 per mile
Total annual costs per mile	$119,000
Cost per acre-foot	$32.80
Pumping costs	4.50
Cost per acre-foot (delivered to distribution system)	$37.50

The above computations, however, ignore the value of the protection and assurance of the continued safe yield of the basin, estimated at 30,000 acre-ft per year. When the values of the safe yield is considered, together with the import required to meet the entire estimated demand of the basin, the cost is modified as follows:

Annual cost of protection for 11 miles of coastline ($119,900 × 11)		$1,318,900
Annual cost of additional water import (49,850 acre-ft at $20.00 per acre-foot)		997,000
Pumping cost (70,150 acre-ft at $4.50 per acre-foot)		316,195
Total cost		$2,632,095
Total required supply—*acre-ft*		
Injected supply	40,150	
Safe yield	30,000	
Required import	49,850	
Total supply	120,000	
Delivered cost per acre-foot		$ 21.90

This latter cost analysis still ignores the value of usable underground storage for fresh water. If it is assumed that the West Coast Basin area were to be supplied entirely by imported water at $20.00 per acre-foot and that a storage of 10,000 acre-ft were required to balance peak demand and emergency storage against supply, then at a minimum figure of $4,000 per acre-foot for surface storage, the required investment would be $40,000,000. Such a sum would indicate an annual amortization charge of approximately $13.00 per acre-foot based on 120,000 acre-ft of annual use. Thus, the total cost of delivering imported water would be about $33.00 per acre-foot, without considering supply lines to isolated water systems, as compared to the $21.90 per acre-foot.

Hence, the application of the actual costs of a proposed sea water barrier and the economic justification of such expenditures must be considered in relation to the value of assuring the protection of the safe yield of the basin, the cost of a supplemental water supply, the cost of distribution facilities for such a supply, and the value of the ground water basin for storage purposes in relation to providing adequate surface storage as well as the intangible value of a safe ground water supply in the event of a local disaster, such as an earthquake or war. Such considerations might easily justify the costs of a barrier project as indicated above.

To improve further the economic aspects of this problem, the Los Angeles Flood Control Dist. is presently engaged both in performing sewage reclamation tests on a source of supply now wasting approximately 300 cfs to the ocean and in evaluating the cost of piping untreated Colorado River water (base cost, $10 per acre-ft) to the distribution line of the sea water intrusion barrier.

Conclusions

The investigation of the prevention and control of sea water intrusion has established that, for an area with comparable geologic and hydrologic condition to the West Coast Basin:

1. Prevention and control can be successfully realized in a confined coastal aquifer by recharge through wells
2. Recharge can pressurize a confined aquifer continually through a given reach, thereby reversing a preexisting landward gradient and preventing further sea water intrusion
3. Recharge will provide significant replenishment to the inland ground water basin with only a relatively small oceanward loss of fresh water.
4. Recharge can be performed in an aquifer previously degraded by sea water intrusion and—within the physical limitations as established at the test site—will not have any consequential deleterious effect on inland pumped supplies. In fact, all evidence collected to date indicates that the degraded portion of the aquifer can be reclaimed by recharge through wells.

The Los Angeles Flood Control Dist. has submitted a detailed report on this test to the State Water Resources Board. After review by the state engineer, the report is expected to be published as a state bulletin.

Acknowledgment

H. E. Hedger is chief engineer of the Los Angeles County Flood Control Dist., and Paul Baumann, Asst. Chief

Engr., is in charge of the district's Dams and Conservation Branch. Work on the project was performed under the direction of Finley B. Laverty and under the general supervision of Herbert A. van der Goot. Field supervision of the project is under the immediate supervision of A. E. Bruington, Assoc. Civil Engr., and E. J. Zielbauer, Dist. Geologist.

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Progress in Ground Water Replenishment in Southern California

James H. Krieger

A paper presented on Apr. 15, 1955, at the California Section Regional Meeting, Riverside, Calif., by James H. Krieger, Attorney, Best, Best & Krieger, Riverside, Calif.

THE South Coastal Area of Southern California poses a unique water problem. This region, depending largely on ground water for supply, is overdrawing its aquifers at a rate of approximately 400,000 acre-ft per year (*1*). Although supplemental water is available from the Owens and Colorado rivers, they have not been tapped to their fullest extent, a fact which allows the underground basins to continue declining. One reason for the underdevelopment of the river sources is a 1949 decision in the Raymond Basin case by the California Supreme Court (*2*), a judgment which was discussed in a JOURNAL article in 1952 (*3*).

Of the potential demand of 5,552,000 acre-ft of water per year in the South Coastal Area, only 2,651,000 acre-ft can be supplied locally (*1*). The balance must come from supplemental sources yet to be developed. Because of this need, the impact of the Raymond Basin decision cannot be overestimated; yet the scope of the problem has been realized, and steps have been taken to solve it, only in the last year or two.

Legal Aspects

The Raymond Basin case decision held that all persons extracting ground water from an overdrawn basin are establishing their rights one against the other under the principles of adverse possession. This means that water rights no longer exist in the conventional sense. An owner of a parcel of land above an overdrawn basin loses any right he may have had in the ground water supply beneath him unless he has pumped water for five successive years prior to the commencement of any suit adjudicating the water rights in that basin. The paper right (the water right created by deed) means nothing, nor does the beneficial use of a certain pumpage necessarily create a right to that amount. The taker may be entitled to only a part of his use.

The California Supreme Court has taken as its basic philosophy the policy of the state, as described in the state constitution (4), to the effect that the general welfare requires putting the water resources of the state to their maximum beneficial use. From this premise, the court reasons that no person should be permitted to sleep on his rights and that the best interests of the people will be served by measuring a person's right by the amount of water he pumps and puts to beneficial use. This is an awkward doctrine in many respects. For example, no one

knows the exact moment a basin becomes overdrawn. Indeed, he may not find out until years later. Nevertheless, his rights depend on the later determination of the theoretical moment when the basin becomes overdrawn.

All these difficulties might be overlooked if the rights in a basin could be adjudicated swiftly and economically. Unfortunately, the two basin adjudications in California have been expensive, and both of them have lasted so long that the actual rights of the parties have changed from the commencement of the suit to the time of its final determination.

Necessity of Pumping

Water users in the South Coastal Area have usually been advised by their attorneys to continue pumping water no matter what the cost, because discontinuance might risk the abandonment of a water right. Most persons have chosen to protect their ground water rights rather than take supplemental surface water from the Metropolitan Water Dist. of Southern California. This wasteful practice persists, notwithstanding a 1951 law, not yet tested in the courts, which provides that no person will lose his right to ground water as long as he puts water from nontributary sources to beneficial use (5). Precautionary consumption may be one reason why only 246,000 acre-ft of the available quota of 1,212,000 acre-ft from the Colorado River were delivered by the Metropolitan Water Dist. in the year ending Jun. 30, 1954 (*6*). The use of ground water, coupled with nine consecutive years of below-average rainfall and a rapidly increasing population, has created a critical situation.

A means of encouraging the employment of water from nontributary sources must be found so that the water users of the area may preserve their ground water while using a part of it. The problem is not only to curtail needless overdraft of ground water supplies, but also to wipe out the accumulated deficit and to make use of the estimated 1,000,000 acre-ft of available underground storage capacity.

Attempt at Solution

The attempted solution has been as unique as the problem itself. Late in 1954 the Water Conservation Assn. of Southern California called a meeting of all parties interested in the problem of replenishing ground water supplies. Many statewide organizations were represented in the gathering, at which particular emphasis was placed on the acute problem of Southern California. A committee of twelve selected to solve the problem was made up of engineers and attorneys, as well as representatives of irrigation districts, water districts, farm bureaus, cities, private utilities, and the state. This group contained a beneficial variety of viewpoints and an interest in many different problems. Instead of recommending local solutions for particular areas or groups, this committee presented ideas which were universal in scope.

The committee drafted two bills: the Water Replenishment District Act (Assembly Bill 2,908) and an act to compel the recordation of water extractions and diversions (Senate Bill 1,557). Both bills, which were passed by the legislature, had the complete endorsement of the Water Conservation Assn. of Southern California, as well as the support of many of the

most influential water organizations in the state.

Replenishment Act

The Water Replenishment District Act authorized the creation of water replenishment districts in the counties of Southern California. Such a district will have many of the powers of most public corporations, but its principal function will be to replenish the ground water supplies of the area within the boundaries of the district. The test of what land is to be included within a district is whether or not the people or property within the proposed area will benefit directly or indirectly from replenishment, as determined by the state engineer.

A replenishment district may raise funds by selling water, placing an ad valorem tax on real property and improvements, or imposing a special assessment on those who extract ground water. Replenishment water may be purchased from a nontributary distributor, such as the Metropolitan Water Dist., and be spread into the underground basin or sold to persons agreeing to discontinue pumping in exchange for such water.

By incorporating in one bill the two principal methods of raising funds for replenishment—ad valorem taxes and pumping assessments—a genuine compromise of viewpoints was reached. There are areas in Southern California that believe a property tax is the best way to share the cost. Others insist that the whole burden should be borne by the pumpers. In the proposed legislation, a replenishment district may use either or both of these methods and may change them to meet varying new situations.

Another genuine compromise was reached in determining who would pay a pumping tax if that method is decided upon. Certain groups feel that the charge should be based on the number of acre-feet each person pumps, regardless of any water rights he may claim to have. On the other hand, people from rural areas where the water rights are long established believe, with equal sincerity, that pumpers should be excused from paying a tax on the amount of water that is theirs by court decree. Consequently, the bill provides that if there is an adjudication of water rights within a replenishment district, the board of directors of that district must exempt from a pumping charge the proportional amount of a pumper's previously adjudicated right in and to the safe yield of the basin. For example, suppose a farmer has continuously pumped and put to beneficial use 100 acre-ft per year for the past 10 years. Further assume that the basin has been overdrawn for at least 5 years. After the replenishment district is formed, a pumping tax is levied on all of the pumpers, including the farmer, who first pays an assessment based on his fractional share of the entire water pumped in the district. If the rights of the water users in that district are adjudicated, however, and the safe yield of the basin is found to be 25 per cent less than the amount being pumped, the farmer is exempt from charges on 75 per cent of the ground water he removes from the aquifer, while he continues to pay a tax on the 25 acre-ft in excess of his adjudicated share of the safe yield of the basin. As the court modifies its decree from time to time, a person's adjudicated right might also change, along with the amount of water exempt from taxation.

Another unusual feature of the bill arose from the fact that some existing

public agencies possessed the facilities to replenish ground water basins, but had no means of raising funds to purchase the necessary water. These agencies felt that they should be permitted to do the job and that no new public corporation should usurp their functions. The bill therefore provides that a replenishment district must explore and determine whether or not there is an agency that can aid in replenishment. If so, and a suitable contract can be arranged, the district must enter into the agreement. Such a procedure, avoiding duplication of effort and facilities, is an obvious saving to the taxpayer.

Recordation of Extractions

Highly important to the solution of water problems in Southern California are means of expediting ground water adjudications. It is so expensive and time consuming to institute and prosecute a basin adjudication, because of the difficulty of compiling ground water data, that few areas have ever undertaken it, and those that did were left unsatisfied. In adjudication suits where the state engineer was required to undertake an investigation (*7*), it took many years to gather the information needed by the court to make a sensible determination. One reason for this difficulty was the refusal of some persons to divulge the amount of their ground water extractions.

The recordation bill requires any person who extracts more than 25 acre-ft of water a year to file a sworn statement with the California Div. of Water Resources giving his total pumpage. If he also diverts more than 3 miner's inches (1 miner's inch equals 1.5 cfm) of surface water, he must report the maximum and minimum flows in each period of diversion. For the first year he must report the quantity of water taken by him, or his "predecessor in interest," for each of the preceding 10 years. Thereafter, he must report the amount drawn annually. If he fails to make these yearly statements, he cannot perfect a prescriptive right to ground water. Just as a squatter must now pay taxes in order to perfect a squatter's right on another's land, a pumper who asserts a prescriptive right to water must record his use. If he does not list the amount for a period of 5 years, he will lose whatever right he may otherwise have had in the ground water basin. Under the rule of the Raymond Basin case, it is apparent that most Southern California rights in ground water are prescriptive, because the ground water basins are being overdrawn. Therefore, a person is compelled to pump and record, or run the risk of losing whatever right he may have.

An interesting feature of the recordation bill is the right of a person to challenge the statement filed with the state engineer under existing adjudication procedure. The cost of the state engineer's investigation of the facts set forth in the statement must be paid by the individual questioning its accuracy. If the state engineer makes a determination which differs from the data contained in the original notice, he must inform the person filing the statement and the person requesting a determination of its authenticity. Both parties are then invited to submit further information before the state engineer makes his final decision. A filed statement is admissible in any court proceeding as prima facie but rebuttable evidence.

Conclusion

The South Coastal Area's water problem owes much of its acuteness to the Raymond Basin decision, which places a premium on continuing extractions of ground water. Practically all efforts to encourage the voluntary use of nontributary waters has failed. Only in those areas (such as Orange County) where replenishment was more important than adjudication have supplemental supplies of water been used. The rest of the South Coastal Area must find a solution to its ground water difficulties.

The Metropolitan Water Dist.'s allocation of Colorado River water must be put to use. Demand must come either from new users or from public agencies equipped to purchase the water and recharge it to the aquifer. The underground storage capacity of Southern California is a valuable resource and should be put to maximum use. The population growth of the region and the current dry spell both accentuate the critical situation.

A committee has sought a solution to the problems by drafting the necessary broad and accommodating legislation, under which the trend of diminishing ground water may be halted, and the original safe yield of the aquifer may be ultimately restored.

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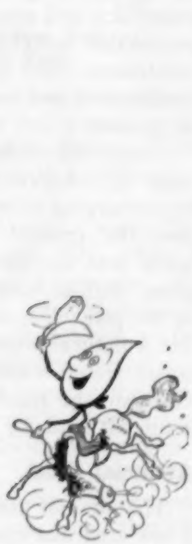

Recharge Operations at Kalamazoo

W. H. Sisson

A paper presented on Jun. 14, 1955, at the Annual Conference, Chicago, Ill., by W. H. Sisson, Constr. Engr., Upjohn Co., Kalamazoo, Mich.

THE Upjohn Co., one of the largest manufacturers of pharmaceuticals in the world, in 1951 completed, 5 miles south of Kalamazoo, Mich., a new manufacturing plant with a total floor area of 2,600,000 sq ft. Inasmuch as large volumes of water of good quality are necessary in the production of pharmaceuticals, efficient use of water was given major consideration in the design of the plant.

From 5,000,000 to 9,000,000 gpd of well water is used. Most of this volume is reused, some as much as five times over. For example, in the main manufacturing building, the water from air conditioning units is collected in reservoirs and reused several times in production vessel coolers, refrigeration condensers, roof sprays, steam turbine condensers, and irrigation of 22 acres of ground.

Since 1952 further efforts have been made to conserve local ground water by recharging clean, warm waste water into the ground. Use of recharge wells was considered, but because a great deal of land area was available at the plant site, it was decided to utilize a natural pond for one of the two waste water sewer outlets and to investigate the feasibility of building an artificial pond for the other outlet.

Artificial Pond

The site for the artificial pond was a low area that could be filled by gravity from the combination storm and waste–cooling water sewer that discharged into a creek 1 mile from the plant. Before any large-scale recharge operation was attempted, it was important to know the rate of percolation and to determine whether the recharge water would flow toward the 100-ft deep pumping wells located 2,200 ft to the east and whether the recharge water would raise the temperature of the well water, which was at 52°F. After auger samples of the glacial drift were taken at the site and found satisfactory, a hole 100 × 100 ft was dug in the low ground and diked. The 2 ft of black top dirt and the 2 ft of impermeable clay covering one-third of the area were removed, leaving a clean sand bottom approximately 5 ft above the static water level. An 8-in. line was connected to the 72-in. combination sewer and fitted with a flowmeter and valves. The pond, which was 10,000 sq ft in area, was filled by Jan. 1, 1953, with water 3 ft deep.

Figure 1 shows the relative location of the pond and the fourteen screened 2-in. observation wells that were drilled at various distances from the pond. The four deep wells went 77 ft below the pond bottom into the artesian aquifer, whereas the shallow wells went 7 ft below the pond bottom into the water table aquifer. Daily readings of static water level and temperature were taken from the wells.

Other data recorded daily were sewer water temperature, pond water temperature, and the flow required to maintain the 3-ft head of water in the pond.

Percolation Rate

The average percolation rate for the 11 months of experience in 1953 was 124,000 gpd, or 86 gpm (see Fig. 2). During the spring rains the pond bottom had gathered some silt, and weed growth became quite heavy. After the pond dried up in July, the bottom was cleaned with a bulldozer, a step which apparently improved the percolation rate by approximately 25 per cent. Bacterial growth caused no difficulty because the well water was initially treated to obtain 0.35 ppm residual chlorine and the storm sewer has a 0.15-ppm residual. During February, March, and April 1954, trouble was encountered with leaves and other debris in the flowmeter, a fact which probably lowered the recorded rate of flow in Fig. 2. Correction for this assumed error indicates an average percolation rate of 106,500 gpd, or 74 gpm, for the first 9 months of 1954.

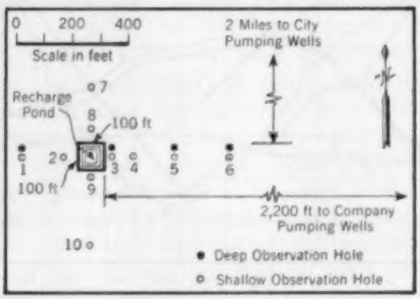

Fig. 1. Area of Artificial Recharge Pond

Fourteen 2-in. observation wells were drilled around the 100 × 100 ft pond.

Recharge Water

Figure 3 shows the rise and fall of the temperature of the underground water in the seven observation wells east of the pond in relation to the temperature of the water in the pond, whose temperature curve shows the effect of the outdoor temperature on the water awaiting recharge into the ground. The average temperature of the sewer water discharged to the pond during the winter and summer was 70°F and 75°F, respectively, with a maximum temperature of 82°F and a minimum of 61°F. The temperature of the pond water was below that of the influent sewer water, except during June and July, when it was approximately 3°F warmer. By averaging the time interval between crests of the curves in relation to the pond water temperature curve and noting the distances between the pond and the observation wells, it was found that the average velocity of the underground water was approximately $1\frac{3}{4}$ ft per day. By similar observations and calculations it was found that the

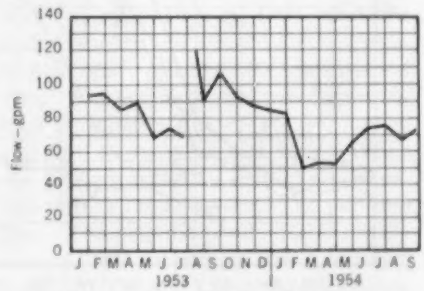

Fig. 2. Percolation Rate of Artificial Pond

Because the pond bottom had gathered silt and weed growth had become heavy, the pond was allowed to dry up in July to permit cleaning with a bulldozer.

water is cooled at the rate of approximately 5.25°F per 100 ft, or 1°F for each 19 ft of travel through the ground. Thus, recharge water at 80°F would be cooled to the normal 52°F underground water temperature by traveling 570 ft from the pond toward the pumping wells.

A typical day's static water level readings in the deep observation wells are presented in Fig. 4. The inverted readings often seemed inconsistent, probably because of the clay strata above and below the well screens, which influenced the percolation into the artesian strata, the curves as a whole did indicate the slope of the water table toward the company pumping wells to the east. The slope is about 0.093 per cent, a figure which closely agrees with observations made in the deep wells.

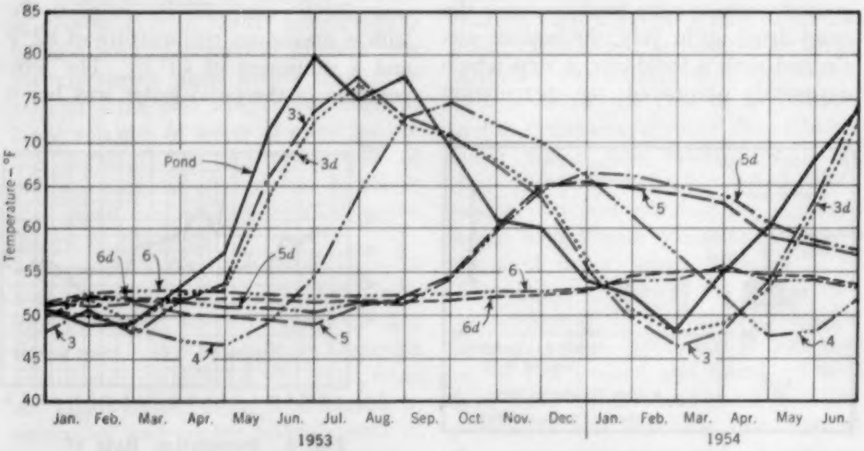

Fig. 3. Temperatures of Recharge and Pond Waters

This chart shows the rise and fall of the temperature of the underground water in the seven observation wells east of the artificial pond, as well as the variation in temperature of the pond water.

drawdown curve is found by connecting the recorded readings. The broken line joining the two legs of the curve at equal distances from the edges of the pond shows the underground hydraulic gradient slope. The slopes average out to 0.108 ft of descent in 100 ft, or a slope of 0.1 per cent toward the Upjohn pumping wells.

Figure 5 shows one day's plot of the typical static water level readings in the shallow observation wells in the east–west direction. Although these

Figure 6 presents a typical day's static water level readings in the four shallow observation wells in the north–south direction from the pond. A hydraulic gradient slope of 0.79 per cent to the north was drawn by connecting two points 200 ft from the outside edge of the 100-ft wide pond. This fall is undoubtedly caused by the draw of the city wells 2 miles north of the Upjohn Co. The northerly slope tends to confirm the belief of federal and Michigan geologists that long before the Kala-

mazoo and Upjohn wells were drilled, the general slope of the water table was to the northwest.

Water Treatment Plant

The main wastes treatment plant consists of pumping units, sedimentation tanks, and trickling filters for a two-stage biological treatment (Fig. 7). The chlorinated effluent flows into the storm sewer about 1,000 ft below the tap for the recharge pond. The combined flows then discharge into a game creek ½ mile away. The Upjohn Co. is held to very stringent loading restrictions on the creek by the Michigan Water Resources Commission and The Michigan Conservation Dept. The recharge pond presents an opportunity to run a continuous check on the quality of the waste water before it combines with the treatment plant effluent. Several hundred game fish, such as bass and perch, were planted in the pond water. The fact that none died during a 20-month test period indicated that no toxic or high-BOD material had been inadvertently discharged into the storm sewer.

The experimental pond proved that use of an open body of water for recharge was successful as far as temperature and direction of ground water flow were concerned. Percolation rate was fair and, therefore, pond recharge would be a good investment and a good public relations gesture. More auger soil tests were made in the earth adjacent to the pond to make certain that further expansion would not be too costly in removing top dirt or large volumes of clay. The borings indicated the presence of more clay and top dirt than in the experimental pond, but not enough to make the job prohibitive in cost. After the necessary excavating was done and the clay removed, the area was diked, fenced, and graded to prevent silting of the pond bottom by rain water runoff from the adjacent hills. When this work had been completed, a combined pond of 50,000 sq ft (1.145 acres) was ready for use (Fig. 8). A removable plank dam was built between the 10,000-sq ft and the 40,000-sq ft areas so that the sections could be cleaned separately and the fish, numbering several thousand, could be herded into the section not being cleaned. The new pond began receiving water on Sep. 28, 1954. Because the maximum flow of the sewer connection was 485 gpm, it was not until Dec. 8, 1954, that the water reached the desired level. Additional head affected the percolation rate. For example, on one day readings indicated a rate of 324 gpm when the head in the pond was 3½ ft. When the head dropped to 3 ft, the percolation rate was 283 gpm, or 12 per cent less. The original pond (10,000 sq ft) cost $1,500, whereas the additional area (40,000 sq ft) cost approximately $4,000.

Natural Pond

A natural pond covering 90 acres, mentioned earlier, is also used as a recharge area, receiving water from another waste water sewer outlet (Fig. 9). This pond, at the opposite side of the company property and about ½ mile from the artificial pond, had no outlet and normally dried up during the summer months. When buildings were raised and small manufacturing operations were started near this area in 1949, waste cooling water and industrial wastes were discharged into the pond. By 1953 the manufacturing operations had greatly expanded, plac-

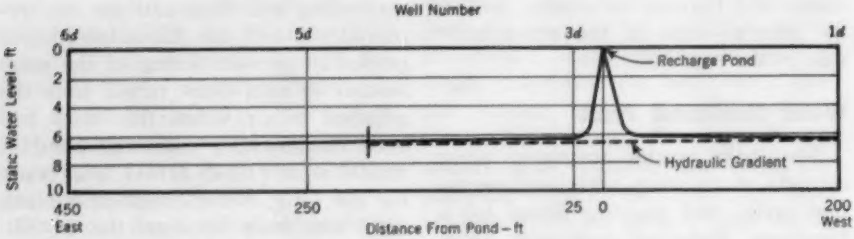

Fig. 4. Static Water Levels in East–West Deep Observation Wells

This chart is a record of static water levels, measured from the pond water level, in the four deep observation wells on Jun. 1, 1954. The hydraulic gradient slope is 0.1 per cent toward the company pumping wells.

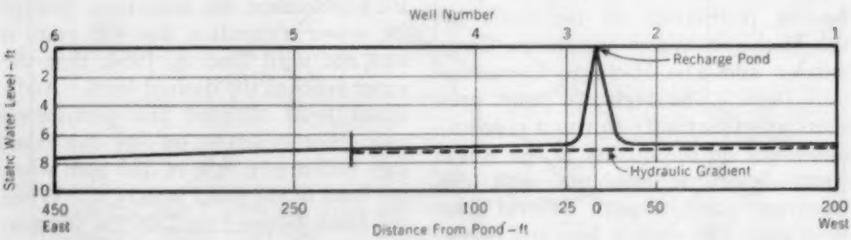

Fig. 5. Static Water Levels in East–West Shallow Observation Wells

Static water levels, measured from the pond water level, in six shallow wells were recorded on Feb. 2, 1953. The hydraulic gradient slope is 0.093 per cent toward the company pumping wells, a figure which agrees with the observations made in the deep wells.

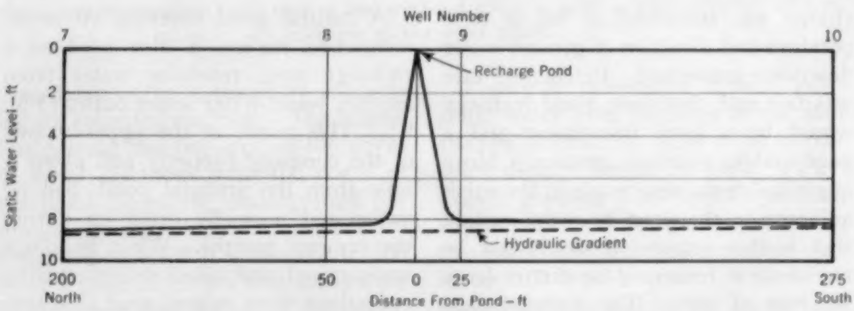

Fig. 6. Static Water Levels in North–South Shallow Observation Wells

The data presented here were gathered on Feb. 1, 1954. The static water level was measured from the pond water level. The hydraulic gradient slope is 0.079 per cent toward the city pumping wells.

Fig. 7. Wastes Treatment Plant

The plant consists of pumping units, sedimentation tanks, and trickling filters.

Fig. 8. Artificial Recharge Pond

The section built first is at the upper left of the addition.

Fig. 9. Natural Recharge Pond

The long wooden flumes are seen as thin lines in the photograph.

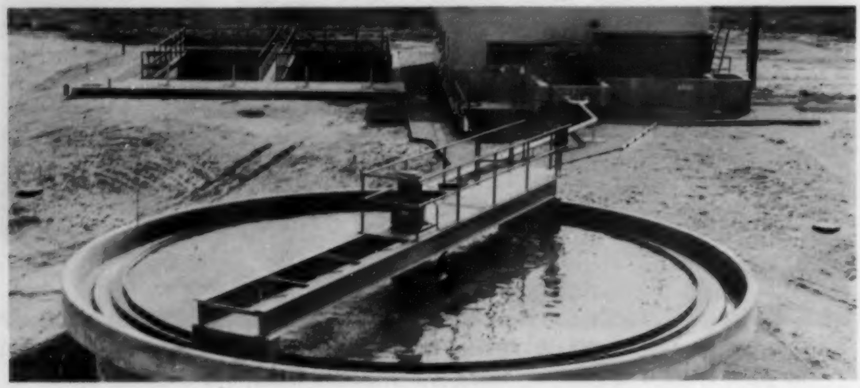

Fig. 10. Disposal-Well Treatment Plant

This treatment plant consists of neutralization, flocculation, clarification, and filtration tanks and injection pumps.

Fig. 11. Natural Pond in Polluted State

The gray, brackish water of this pond is an indication of its highly polluted state.

Fig. 12. Natural Pond in Uncontaminated State

This photograph was taken a few months after the disposal well–treatment plant had gone into operation.

ing a very much increased industrial-waste load on the pond. The total volume of water entering the pond and percolating into the ground was 1.5 mgd. The pond was developing objectionable odors, with the presence of anaerobic gas, and concern was felt about the effect of the foul water on the pumping wells. The BOD-digesting capacity of such a pond was not known and was difficult to determine. It was noted, however, that a large part of the 20,000 lb of BOD per day going into the pond consisted of organic solvents with persistent odors. Long wooden flumes were built to distribute the waste better over the pond. This procedure was of considerable help, but it was apparent that the loading was too great and that additional measures would have to be taken to prevent contamination of the pumping wells 800 ft distant from the pond. Samples of water taken from small test wells drilled between the pond and pumping wells were found to have a high BOD, a disagreeable odor, and a high bacteria count; *Esch. coli* was present. Further, the water specimens were fatal to *Daphnia*, an indication that the water was toxic. The use of the pumping wells near the pond was discontinued in order to divert the polluted water, and work was started at once to obviate further dumping of industrial wastes into the pond.

A program to reduce the volume of contaminated waste water in the manufacturing building saved about 550,000 gpd. The greatest part of the saving was made in connection with the large number of steam vacuum jets used in the area. It was found that these jets could exhaust to the atmosphere, thus, dispensing with the water contact condensers. This change in operation, along with other measures, reduced the water consumption and the load on the industrial sewer for that area from 620,000 to 70,000 gpd. The industrial sewer–load reduction, incidently, greatly simplified the design conditions and reduced the cost of the new wastes disposal plant, which it was necessary to build.

Disposal Wells

Because the waste volume was reduced to less than 100,000 gpd, with a BOD of 5,000 lb per day, it appeared best to investigate the possible use of brine strata disposal wells in order to obviate an expensive biologic–treatment plant. Very little could be determined about the possible injection rate or the compatability of a brine strata well with the wastes without actually drilling a well. After the first well, drilled to a depth of 1,532 ft, gave a satisfactory injection test into the Traverse and Dundee formations, a second injection well, 1,476 ft deep, was also completed.

The preliminary treatment plant units that were built consist of neutralization, flocculation, clarification, and filtration tanks, as well as two 50-gpm, 1,000-psi injection pumps, placed in service in November 1954 (see Fig. 10). The waste is being disposed of safely away from the potable water supply with the full approval of the Michigan Conservation Dept. and the Water Resources Commission. Note the gray, brackish appearance of the water in Fig. 11 and compare it with Fig. 12, which is a photograph of the pond a few months after the disposal-well plant went into operation. The pond is now recharging about 1 mgd of clean waste water. The polluted water

that has entered the pumping aquifer is still being traced by use of observation wells. It is hoped that the water will be moved around, filtered, and diluted by alternating pumping well operations and will cause no trouble.

Conclusions

1. A reasonably rapid percolation rate is possible in the particular soil at the site of the manufacturing plant, making feasible the use of artificial recharge ponds.

2. As large a head of water as possible, consistent with the gravity flow from the sewer (to reduce pumping costs) is an advantage to the percolation rate.

3. The outdoor-air temperature lowers the temperature of the pond water awaiting recharge into the earth. During the winter, the water is cooled about 23°F. This effect is an advantage of recharge ponds over recharge wells.

4. The earth cools the recharge water, whose velocity is $1\frac{3}{4}$ ft per day, at the rate of 1°F for each 19 ft of travel through the earth. These facts permit estimation of how far a pumping well should be from the recharge area in order not to affect well water temperature.

5. The recharge water flows into the "drawdown cone of depression" of the company's wells, and the cone is tipped toward the Kalamazoo wells; thus, both of the large water users, as well as others, benefit from the recharging.

6. There is real contamination danger to nearby wells when poor quality water is recharged into the ground.

7. The proper design and operation of waste treatment plant facilities is essential in safeguarding streams and underground water.

8. Brine strata wells are a good means of waste disposal when the proper conditions exist.

9. The new enlarged artificial pond recharges 9 per cent and the natural pond 16 per cent of the well water drawn from the ground.

AWWA Safety Manual

Part 3—Safe Working Practices

After several years of study, AWWA Committee A2.E—Safety Practices has prepared a manual of safety practices for water utilities. The document is divided into four parts, the first two of which were printed in the July 1955 issue, beginning on p. 637. Part 3, because of its length, is being published in several installments, the first of which began in the August 1955 issue, starting on p. 791. When serialization is completed, the manual will be made available as a separate volume for easy reference.

Section 11—Power Shovels and Draglines

1. Allow only authorized men to operate power shovels or draglines; require operators to wear hard hats.

2. Inspect equipment and be certain that it is in safe operating condition.

3. Do not allow anyone to stand, walk, or work under suspended loads or booms. Be sure that people will not be caught by the swing of the machine cab.

4. Avoid overloading buckets or booms. Know the safe load limit of the equipment. The manufacturer's limitation for loads at various angles of the boom should be listed or posted in the cab and strictly observed.

5. Do not undercut the bank when moving earth.

6. Be certain that the driver of the truck or engine has dismounted and is in the clear before swinging a load over the equipment.

7. Load dump trucks or cars evenly so that material does not overhang the sides.

8. Shut off the power and secure all movable parts before leaving the machine. Keep floors and running boards free of grease, oil, and debris.

9. Lower the boom and rest it upon a horse or suitable support if the machine is to be idle for long periods of time.

10. Use a handhold for getting off or on the equipment; do not jump.

11. If a signal man is needed, appoint one and follow only his signals, which should be standard ones.

12. Avoid proximity to all electric wires. Maintain a reasonable clearance (8 ft) from primary circuits. When a crane boom is operating near power wires, instruct personnel not to touch the suspended load. If the boom should accidentally touch the wire, the operator may be seriously injured.

13. Keep the crane or dragline as close to level as possible before lifting heavy loads, in order to prevent overturning the equipment.

14. When leaving the equipment, be sure to set the brakes, secure the boom, lower the dipper and bucket to the ground, and take the engine out of gear.

15. Before lifting an unusually heavy load, first test the brakes by

trying a short lift to make sure the load is under full control.

16. If a load does not ride properly when raised, lower it, and have the sling or slings adjusted.

17. Never allow anyone to ride on loads or buckets.

18. When moving a crane or dragline with a suspended load, try to avoid uneven ground.

19. Do not allow people near enough to be hit by swinging loads.

20. Use a tagline to prevent the load from spinning.

Section 12—Pipe

Handling

Because handling pipe is no job for an amateur, only trained and skilled men using suitable and adequate equipment should be given the assignment. Successful, safe completion of work involving pipe handling also rests on following a proved method; do not take undue risks with the safety of the crew by trying unconfirmed short cuts, because the time saved is not worth the chance of a serious accident. These tested procedures for handling pipe should be carefully followed:

1. Take the utmost care to see that members of each crew work together in moving pipe by hand. Accidents sometimes result because one man starts to lift or lets go of the load before the others are ready. The use of standard signals is recommended.

Fig. 14. Unloading of Pipe

The pipe is being unloaded from the truck with the aid of skids and two snubbing ropes. The workmen are carefully staying out of the path of the pipe.

2. Use a U-shaped carrying bar, carrying tongs, or pipe sticks that are adequate for the pipe's size and weight; do not use makeshift tools. Pipe over 8 in. in diameter should be handled with mechanical aid.

3. Take a firm grip on the lifting bar or tongs, and be sure the hold will not slip.

4. When lifting or lowering a weight, bend the knees, placing the

load on the leg and thigh muscles, not on the abdominal and back muscles; keep the back fairly perpendicular.

5. Lift and lower at a given signal by the man in charge, so that all members of a crew move together. Avoid sudden starts or stops.

6. Skids should be of ample strength, and should be securely placed.

7. When unloading pipe from trucks or cars, lower individual pieces by snubs all the way down the skids (Fig. 14).

8. Do not stand between the skids while pipe is being lowered.

9. Before snubbing operations are begun, inspect the ropes carefully for defects.

10. Wear gloves for all snubbing operations, as slipping rope may cause burns on bare hands.

11. Take every precaution to prevent the uncontrolled rolling of pipe, as a rolling pipe is dangerous. Use wood chocks when necessary.

12. When manually lifting or lowering pipe in a trench, use two or more rope slings, looped under the pipe, and handle from each side of the trench. To prevent men from being pulled into the trench by a heavy pipe, anchor one end of each rope sling to a massive object, such as a truck.

13. When aligning pipe in the trench with either manual or mechanical power, keep hands and fingers away from ends of pipe and other substructures that may cause injury by crushing.

14. Govern crane operations by the signals of a qualified crewman only.

15. Never attempt to catch and hold a length of pipe that appears to be slipping from a sling handled by a crane or hoist.

16. Be alert to unsafe conditions of trench sides when measuring, testing, or inspecting pipe in place on a trench bottom.

17. When cutting sections of pipe, keep feet in the clear and use adequate blocking, chocks, or pipe vises, to prevent pipe movement during the process. Wear safety goggles.

18. Keep tools and appliances in good condition for the handling, cutting, threading, or treatment of pipe. Use the right tool for the job.

Fig. 15. Stacked Pipe

The pipe is stacked four rows high with 2-in. by 4-in. separators and wooden wedges. Note that the pipe is alternated end for end.

19. Do not let tools or materials become stumbling hazards where pipe is being handled.

20. Avoid short cuts and makeshift methods that may increase the hazards of handling pipe.

Storing

1. Small pipe should be stored in racks according to lengths and sizes.

2. Pipe should always be blocked to prevent it from rolling or falling.

3. Threaded pipe should be handled with care, for threads are sharp and can easily cut the flesh.

4. Pipe larger than 2 in. in diameter should be stacked in storage with spacing strips placed between each row.

5. Each row of stacked pipe should be arranged and blocked to prevent its rolling from the pile. All blocking should be of reasonably permanent material, such as chemically treated wood (Fig. 15).

6. A pipe unit should never be withdrawn from a lower row.

7. In pipe storage areas, or where allied pipe material is handled by a crane, men should be conversant with the signals used by the operator and be careful to stay clear of the load's path; standard signals only should be used.

8. Pipe yards and walkways should be maintained in a clean and orderly manner at all times (see Fig. 16).

Fig. 16. Storage Yard

The stock is neatly piled, leaving uncluttered aisles. Painted lines designating aisle boundaries would be helpful.

Section 13—Lead and Calking Compound Melting and Handling

Lead Melting

1. Conduct lead-melting operations in such a location and in such a manner that the actual contact with, or the spillage of, the hot material is minimized. Take special precaution whenever the work is performed in an area where the spillage could endanger workmen in vaults, trenches, or other excavations.

2. Do not put wet material or water into the molten lead or add large quantities of lead to the melting pot suddenly, as such action is the frequent cause of explosions of the lead pot.

3. While the lead is melting, also heat the ladle to evaporate any moisture that might be present in it.

4. Be sure to preheat new lead before adding it to already molten metal.

5. When lead is to be added to, or drawn from, the pot, always wear gloves or mittens, have sleeves rolled down, use a face shield, and wear high-top shoes (see Fig. 17).

6. When pouring lead, be certain that the footing is secure; wear gloves; have sleeves rolled down; and wear a face shield. Take a position in *back* of the bell or sleeve opening (Fig. 18). If the joint contains moisture, pour in a small quantity of oil before the lead.

Fig. 17. Addition of Lead to Melting Pot

The workman is fully clothed, including a face shield, to avoid exposing any part of the body.

7. Make sure that the path of travel from the lead-melting operation to the point where the lead is to be poured is unobstructed. Warn all workmen along the route to be alert and stand clear when hot material is being carried.

8. Personal cleanliness will greatly aid in reducing the hazard of lead poisoning; wash hands and face before eating or drinking.

9. Use proper personal protective measures, such as adequate clothing (with sleeves rolled down), gloves, and eye shield while handling molten metal.

Calking

1. Only those men actually engaged in calking should be permitted in the immediate area.

2. A calking operation should be free from distractions or unsafe conditions that could contribute to an accident.

Fig. 18. Pouring a Joint

The workman's body is fully covered with clothing, gloves, and face shield. He has not taken the precaution of wearing a hard hat.

3. A calker should maintain and use only tools that are approved and in good condition.

4. Adequate eye protection should be worn during use of impact tools.

5. Adequate work space should be provided around the joint to be calked.

Compound Melting

1. When calking compound is melted, unnecessary contact with the

fumes of either the primer or the compound should be avoided, especially when using bitumastic or phenolic compounds. To reduce the hazard of burns from fumes retained in the clothing, it should be changed and cleaned every day.

2. When it is necessary to carry the hot material in buckets, they should be riveted for additional protection.

3. Hot compound should be carried in closed buckets constructed for that purpose; not more than a single bucket should be carried by one man, as the bearer should have a hand free to assist in the prevention of accidents.

4. Handlines should be used to raise or lower the buckets containing hot material.

5. The kettle valve should be opened slowly to avoid a splashing of the hot compound.

6. The kettle should never be left unattended while the contents are hot.

Section 14—Barricades and Warning Signs

1. Warning signs should be placed well ahead of construction or repair areas to warn traffic of the hazard. planks to provide a safe working space. Flagmen to direct and slow down traffic may be essential in some areas.

Fig. 19. Barricaded Work Area

The safety precautions taken protect both the workmen and the traffic. The compressor is located between the excavation and the oncoming automobiles. Hard hats are being worn by the men in the trench.

2. Suitable barricades or other warning devices should be placed far enough from work areas safely and suitably to divert both foot and vehicular traffic.

3. The work area should be protected by barricades, barriers, or Where trucks or air compressors are used, they should be stationed between the work and the traffic (see Fig. 19).

4. During periods of reduced visibility, suitable, adequate lighting should be used in addition to other protective measures.

5. Adequate barriers, barricades, lights, and signs should be placed to warn and divert traffic during periods in which no work is in progress. More than one light should be used for each job; reflecting tape on barricades may reduce the number of lights required.

6. The construction and placement of warning devices should conform to local traffic requirements and regulations.

7. In winter, it may be necessary to stop traffic from using streets covered with surface ice resulting from a main break until a sanding or scarifying operation may be completed and traffic resumed under safe driving conditions.

Section 15—Concrete Mixers

1. Before a concrete mixer is moved, securely fasten the hitch. The use of properly secured safety chains are recommended.

2. Obtain adequate help to handle the tongue when connecting or disconnecting it from a trailer hitch. A mixer in tow should be moved backwards only when a signalman instructs the driver to do so.

3. Keep mixers level to prevent tipping. On a hill, blocks the wheels, and before leaving the mixer, lower the skip, set the brakes, and turn the switches off.

4. Before starting the engine, place the control in neutral. Run the engine for at least 5 min before engaging the clutch. Find out the cause of an engine backfire at once.

5. Be certain everyone is out of danger before the skip is moved up or down. When maintenance or repair of a mixer is being conducted, be sure the skip is in a lowered position.

6. To crank a motor, keep the thumb beside the other fingers and pull up a quarter turn; better, use a rope.

7. Keep away from the drum opening when the mixer engine is running. Guard belts, gears, pulleys, flywheels, and rollers.

8. When exposed to cement dust, wear a dust respirator and tight-fitting clothes.

9. Wear goggles when cleaning hardened concrete from drums, as well as at any other time of exposure to flying substances.

10. Stop the engine and lock it before entering the drum or making repairs.

11. To prevent burns or scalds, do not refuel the mixer engine while it is running or hot; use extreme care when adding water to a hot radiator.

12. Keep the mixer clean, and do not allow waste material to accumulate in or around it.

13. Mark the mixer with a red cloth flag by day, a red light at night.

Willing Water Says:

A good safety program is cheaper than a high accident rate.

Fig. 20. Standard Signals for Locomotive Cranes

These signals should not be confused with those shown in Fig. 21 for overhead traveling cranes. The illustrations are taken from Accident Prevention Manual for Industrial Operations, *published by National Safety Council, Chicago, Ill. (2nd ed., 1951), Chap. 12, p. 19.*

Section 16—Hoist Operations

Air Hoist

1. Permit only authorized personnel to manipulate air hoists.

2. Before operating a hoist, be certain that it is in good working condition, that the wire rope or chains are not defective, and that the hook is not bent.

3. Always use any existing safety device designed to prevent the sling or chain ring from jumping off the hook or beam.

4. Always try to center the hoist over the load before lifting.

5. Allow for any possible swing when the load leaves its resting place and stand to one side when making the lift if the load is attached at an angle to the hoist.

6. Manipulate the controls to lift the load slowly.

7. Do not stand or allow anyone else to work or stand under suspended loads.

8. If it is necessary to work under a suspended load, block it up so that it cannot descend if the mechanism should fail.

9. Never lift a load on the point of the hook.

10. When moving a hoisted load, always push it, rather than pull, in order to keep feet out of danger if the burden should fall.

11. Keep hands from places where pinching is likely to occur.

Locomotive Crane

1. Permit only authorized personnel to operate a crane or hoist.

2. Check to ascertain that a crane or hoist is in good condition before operating the apparatus.

3. Test all hoist limit controls and brakes at the beginning of each shift, as well as every boom support and clevis pin.

4. Before handling an unusually heavy load, test the brakes on a short lift to make sure full control is available.

5. Appoint a signal man and move the load only at his signals, which should be standard ones (Fig. 20).

6. Be certain that everyone is safely out of the way before moving a load.

7. Lower a load which does not ride properly when raised and have the slings adjusted.

8. Do not carry loads over men, and do not let anyone walk or stand under a suspended burden or the boom of a crane.

9. Avoid uneven ground, if possible, when moving a crane which has a load hanging from the boom.

10. Never allow anyone to ride on loads or hooks.

Willing Water Says:

Committee work stimulates interest in maintaining a safety program.

11. Avoid close proximity to electric wires.

12. Place the bucket on the ground when the crane is not in use.

13. Lower all crane or dragline booms on a horse or other support during overnight inactivity.

14. Require all personnel working with lifting equipment to wear hard hats.

Overhead Traveling Crane

1. Permit only authorized personnel to operate a traveling crane.

2. Use both hands when climbing to or descending from the crane cab; lift tools and materials to the cab with a handline.

3. Lock open the main power switch of a crane if repairs are to be made.

4. Keep unauthorized persons off the crane.

5. Be certain that controls are in the off position before opening or closing the main switch.

6. Inspect all crane equipment on each shift; make sure that circuit breakers, limit stops, brakes, and all other safety devices are operative; check the condition of the hook and wire rope.

7. If the power should fail, move the controls to the off position at once; wait until the signal lamp lights before turning the controls to the on position.

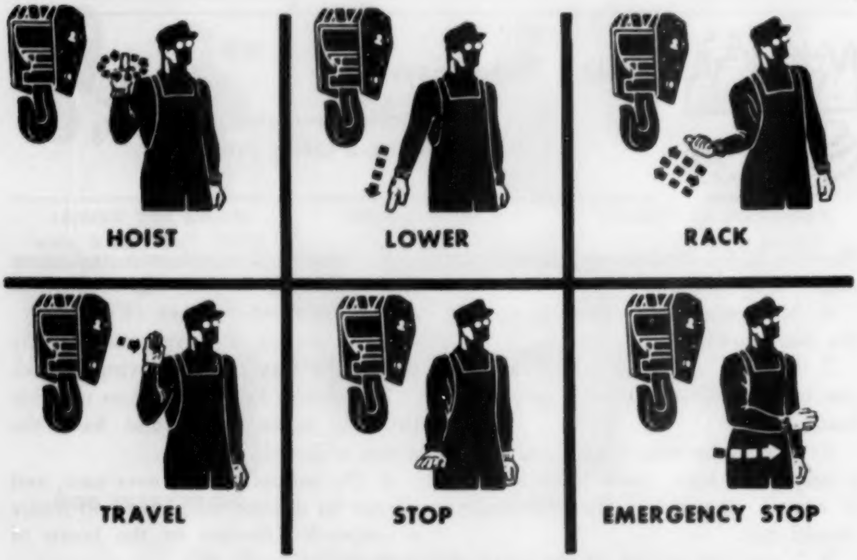

Fig. 21. Standard Signals for Overhead Traveling Cranes

These signals are not the same as those used for locomotive cranes (Fig. 20). The illustrations are taken from Accident Prevention Manual for Industrial Operations, *published by National Safety Council, Chicago, Ill. (2nd ed., 1951), Chap. 12, p. 14.*

8. Never depend on a limit switch to stop the motor; use the controls for this purpose.

9. Be certain that all signals are clearly understood; observe the details of loads being moved and, if anything seems unsafe, stop the crane until the situation is corrected.

10. Use only standard signals to control crane operations (Fig. 21).

11. Do not move loads over the heads of workers or allow them to walk, stand, or work under a suspended burden; when moving loads in populated areas, sound a warning signal and make sure that everyone moves to safety.

12. Whenever the crane is left, place all controls in the off position, open the main switch, and set the brakes.

13. Require all personnel to wear hard hats.

14. Use only approved equipment for lifting all types of material (see Fig. 22).

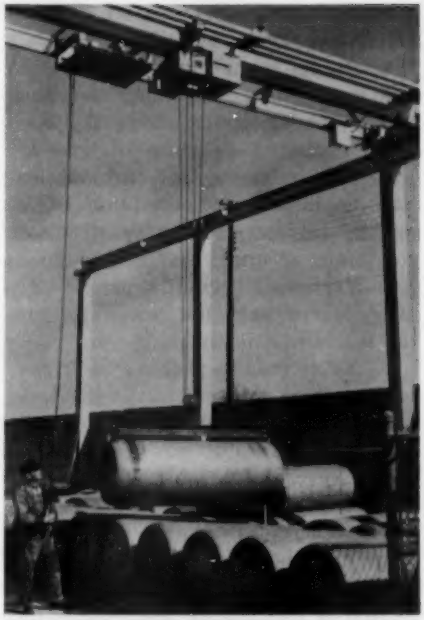

Fig. 22. Use of Overhead Traveling Crane

The operator is raising a 1-ton container of chlorine which is held by an approved lifting clamp.

Section 17—Pumping Stations

Danger is always present where machinery, such as pumps and motors, is operating and where high-voltage electricity is used. Undoubtedly, pumping station operators have the highest respect for the hazards involved in their occupation. Unfortunately, familiarity tends to breed carelessness and complacency. Constant attention and alertness is the best way to avoid injury. Never be caught off guard. Carefully follow the safety precautions presented in this section.

Warm-Weather Operation

Gates placed across door areas to allow ventilation while excluding unauthorized persons are recommended.

Oiling

1. Stop machinery before cleaning, oiling, or adjusting it.

2. Lock the switch gear so that no one can start a machine being worked on.

3. Before starting a machine, be certain that personnel are clear of danger

and that working parts are free to move without damage.

4. Apply enough oil or grease to give good lubrication without overflow.

5. Wipe up immediately all spilled oil or grease.

6. Take advantage of each lubrication to inspect the condition of all visible machine parts; report unsafe conditions at once.

7. Replace all guards immediately after lubrication and before starting the machine.

8. Never point a grease gun at anyone or shoot grease into the hand.

9. Take sufficient time to handle tools properly.

10. Never leave tools where someone may trip over them.

11. Where machines or machine parts must be lubricated while in motion, the lubricant fittings should be located at least 12 in. from dangerous moving parts, unless a pipe extends from the fitting outside a guard.

Repairs

1. Lock the controlling switch gear before beginning work, so that the machinery cannot be started by another person.

2. Place substantial blocking under any equipment suspended or supported by jacks or a chain hoist before commencing work.

3. Assure proper ventilation in the work area.

4. Use only solvents having flash points of 100°F or higher. (Petroleum solvents, such as Stoddard solvents and kerosene, have high flash points and are sufficiently effective for the cleaning operations involved in the maintenance of automotive equipment. The volatility of such agents is low enough to prevent reaching hazardous concentrations in workrooms of ordinary size at common temperatures.)

5. Do not use solvents in confined places, such as tanks and pump pits, without good mechanical ventilation. (Petroleum solvents have an anesthetic action in high concentrations and all the commonly used volatile solvents are toxic to some degree. Benzol (benzene) is highly toxic, although its kindred substances, toluol (toluene) and xylol (xylene) are less toxic and, therefore, less dangerous. Wood alcohol or methanol (methyl) is a strong poison. Other alcohols vary widely in toxicity, but in general are less poisonous than methanol. Petroleum solvents, such as the naphthas, and many trade name compounds, such as Stoddard solvents, are relatively nontoxic.)

6. Exercise caution in the use of solvents whose complete composition is not presented on the container. (Trade name compounds may contain benzol or other highly toxic substances. Commercial grades of relatively nontoxic solvents may contain considerable

Willing Water Says:

Whatever the job, it can be done safely.

amounts of highly toxic materials as impurities.)

7. Do not use gasoline, carbon tetrachloride, or other highly toxic or low flash-point cleaning agents. (Kerosene, Stoddard solvents, petroleum naphthas, and methyl chloroform (1,1,-1-trichloroethane) are reasonably safe. The last-named substance is nonflammable.)

8. Keep a suitable fire extinguisher near at hand and ready for use.

9. Maintain sufficient labor and hoisting equipment on the job to handle heavy objects.

10. Examine tools and keep them in safe working condition.

11. Secure unbolted heavy objects if it is necessary to leave the work place.

12. Keep goggles within easy reach, and wear them when eye protection is needed.

13. Keep aisles and open spaces on the floor free of tools and other objects.

14. Change clothes that become soaked with oil or gasoline rather than risk a dangerous fire.

15. Do not consider a job completed until after it has been checked to make sure that lock washers, cotter pins, and safety devices are in place.

Guards

1. Guards should be adequately secured in place in order to shield, fence, rail, enclose, or otherwise guard prime movers, power transmission equipment, and machines and machine parts. (Such procedures will protect employees against exposure to, or accidental contact with, dangerous moving parts.)

2. Guards should be provided with hinged or removable sections at places where it is necessary to change belts, make adjustments, or admit lubricants.

3. Where the guard or enclosure is within 4 in. of a moving part, the maximum opening in the screen should not exceed $\frac{1}{2}$ in.

4. Where guards are located more than 4 in. and less than 15 in. from a moving part, the maximum opening should not exceed 2 in.

5. Standard railing guards should be placed not less than 15 in. nor more than 20 in. from moving parts.

6. The guard should be strong enough to provide real safety; guard structures should be so constructed that they cannot be pushed or bent against moving parts.

7. Guards should be removed and replaced for maintenance only when the machinery is not in operation.

Electric-Switch Panels

1. Switchboards should be located and constructed in a manner which will reduce the fire hazard to a minimum.

2. Switchboards should be located where they will not be exposed to moisture or corrosive gases.

3. Adequate illumination should be provided for the front of all switchboards and for the back of those which have parts or equipment requiring adjustment, replacement, or repair.

4. Clear working space of adequate size and secure footing should be provided and maintained about all switchboards and motor control equipment.

5. Special insulating mats should be placed on the floor at all switchboards.

6. Open switchboards should be accessible only to qualified and authorized personnel and should be properly guarded or screened.

7. All electrical equipment, including switchboard frames, should be well grounded.

8. Permanent and conspicuous warning signs should be provided for panels carrying more than 600 v.

9. Areas screened off because of high voltage should be provided with locks that open from the inside without keys.

10. Lock switches should be open and properly tagged when men are working on equipment.

11. Fully enclosed, shockproof panels should be used when possible; such equipment should be provided with interlocks so that it cannot be opened while the power is on.

Transformer Stations

1. Water utility employees should be sufficiently familiar with the layout and construction of transformer stations so that they can safely perform routine inspection and minor maintenance, as well as recognize and report major damage, dangerous conditions, and other troubles for correction by power company personnel. Plans of the electrical system should be available at each station. The types of sta-

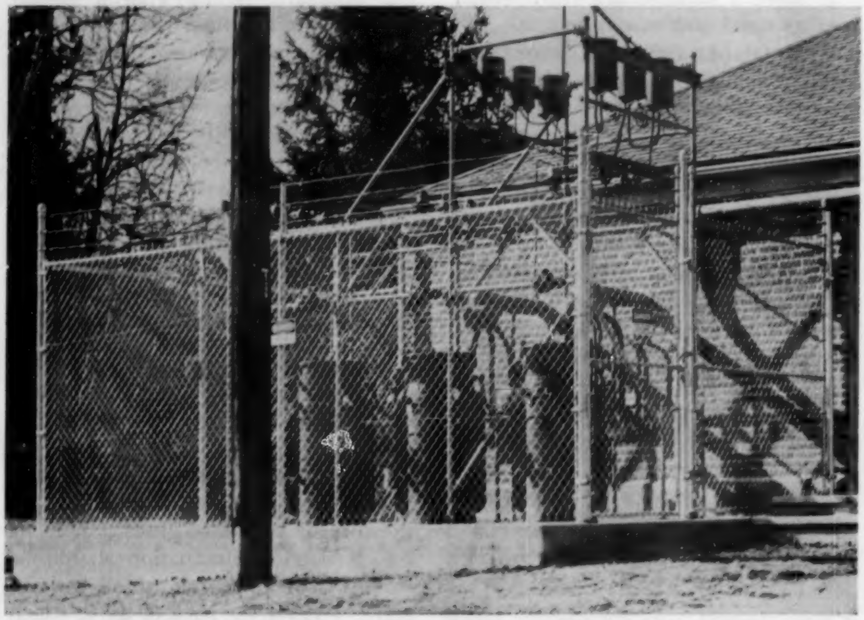

Fig. 23. Transformer Station

The high, substantial fence with warning signs and a locked gate is a commonly found safety measure. The surrounding area is maintained in excellent order, without tall weeds or brush.

tions normally found in water works installations include:

a. Two-Pole Structure, consisting of two 35-ft poles with horizontal timbers mounted approximately 12 ft above ground to support transformers. Associated equipment, such as disconnects, and lightning arresters, is normally installed on the cross arms of one pole. No enclosure is required in the two-pole type of station.

b. Ground Platform, consisting of a concrete pad or base with two 35-ft poles at either end of the pad. Transformers are placed on the pad below the high voltage bus, which is normally 8 ft above the base; associated equipment is installed on the crossarms of the incoming-line pole. The station is enclosed with a chain link fence of sufficient dimensions to give required inside clearances. The gate provided on one side has a lock. The structures and the fence are grounded. Warning signs are placed on all sides of the enclosure. If a building wall forms one side of the area, all windows and openings are screened and barred (Fig. 23).

c. Vault, consisting of a fireproof room—generally within a building—with minimum dimensions of 8 ft × 20 ft; ventilators to the outside provide adequate cross ventilation. Entry is by an approved fire door without self-locking devices. A sign warning of high voltage is prominently displayed on the outside of the door. The high voltage bus generally extends from one end of the vault to the other, in the form of a strain bus (with protecting fuses) mounted on stanchions. The incoming line to the vault may enter either overhead from a pole and down a standpipe or underground from a manhole. All low-voltage equipment is located outside the vault.

2. Employees should be alert to recognize and report as soon as possible any dangerous or defective condition or vandalism. If a hazard is found, a person should remain on guard or adopt other means to prevent accidents and injury to others. Fallen cables, wires, timbers, or other objects should be reported immediately.

3. The location and use of fire extinguishers should be familiar to employees. Soda-acid extinguishers should never be used in the vicinity of live conductors; carbon dioxide or dry-powder extinguishers are recommended. Extinguishers should contain only nonconducting materials and should be inspected at intervals to insure good condition.

4. Enclosure gates and vault doors should be kept securely locked at all times except when entry is required, and only qualified employees should have keys.

5. Poles should be periodically examined for decay at the ground line with a sharp, pointed tool or bar. Poles should be tapped above the ground line with a hammer for evidence of decay or dry rot.*

6. Structures and fences should be inspected at regular intervals to insure that they are in place, undisturbed, or undamaged.*

7. The area within and near enclosures should be kept clear of tall grass, weeds, and brush.*

8. Good housekeeping should be practiced at all times. Approaches

* These duties should be completely restricted to employees of the power company, unless the water utility has a competent electrical staff and the electric company agrees to permit such personnel to make inspections.

and aisles to gates and doors should be kept clear. Enclosures and vaults should never be used for storing tools and materials.*

9. All of the warning signs should be checked periodically and kept in good repair.*

10. Vaults should be inspected for vapors and abnormally high temperatures; all types of stations should be checked for leaking oil.*

11. Extreme care should be taken in working about installations. It should be assumed that the transformer is energized unless it has been proved otherwise by test. In absence of such proof, all safety precautions should be observed for presence of full voltage.

Section 18—Diesel and Gasoline Engines

Gasoline and Oil Storage

The storage of flammable liquids is controlled by agencies interested in fire prevention. Because safety requirements vary with different localities, and even different sections of the same locality, it is recommended that the approval of these organizations be secured for storage facilities:

1. Local fire department
2. State fire marshal's office
3. Fire insurance examiner's office
4. Fire insurance rating inspection bureau
5. Local and state building inspection bureau.

The following admonitions on gasoline and oil storage are considered sound, although they may not apply in their entirety to all conditions and localities:

1. Store large quantities of gasoline and oil underground outside of buildings, in accordance with established ordinances. (Oil in small tanks and drums may be stored above ground in open-face buildings having ample ventilating facilities.)

2. Use approved safety containers at all times when transporting and storing gasoline and oil in small quantities. (Gasoline may be stored inside in quantities of not more than 10 gal; in some areas, this limit is 5 gal.)

3. Provide adequate ventilation.

4. Never fill tanks or small containers to capacity. Allow space of at least 3 per cent for expansion due to increased temperature.

5. Keep all tanks and containers closed, except when filling or emptying.

6. Do not place small containers within 10 ft of stairways, exits, or passageways.

7. To eliminate all possible chance of igniting gasoline or oil:

a. Arrange a standard procedure for filling and emptying containers.

b. Control static electricity by grounding tanks, hoses, and, receivers.

c. Keep a constant and good contact between the nozzle and the gas tank.

d. Do not transfer gasoline during electrical storms.

e. Use vapor-proof lighting and flash-proof electrical equipment.

f. Prevent excessive rise in temperature; do not store flammable liquids in the sun.

g. Keep gasoline away from open flames or heating units.

8. Practice meticulous housekeeping:

a. Attempt to avoid spilling liquids, and wipe up all overflow immediately.

b. Store used waste in covered metal containers until disposal.

c. Prevent accumulating flammable materials.

* See footnote on preceding page.

9. Do not permit smoking; maintain prominent "No Smoking" signs.

10. Know the location of all exits.

11. Do not place gas tanks of engines above the carburetor, because a stuck carburetor float causes gas spillage; use a fuel pump rather than depend on gravity.

12. Know the location and type of fire-fighting equipment and its method of use:

a. Provide approved types of extinguishers.

b. Check them at regular intervals to insure working order.

c. Keep the area around extinguishers clear of all storage and other obstructions which will block quick access in an emergency.

Starting

1. Before starting an engine:

a. Make sure that all guards around moving and rotating parts are in place.

b. Remove all tools that are near the engine.

c. Make sure that floor in vicinity of engine is clean and in orderly condition, as well as free of all spillage of oil, grease, gasoline, and water.

d. Check to see that all personnel are clear of danger.

e. Inspect for the presence of gasoline or oil vapors.

2. Use the recommended safety grip (thumb not around the handle) when it is necessary to crank an engine by hand.

3. Make certain that the compressed-air equipment used for diesel starting has the proper pressure; never, in any emergency, use other bottle gases to start a diesel.

Gearshift

1. Be thoroughly familiar with the manufacturer's instructions for operating and servicing machinery.

2. Place the shift in neutral before starting the engine.

3. Keep guards in place at all times.

4. Check to determine that the suction and discharge valves of pump lines are in the proper position before operating the gearshift.

Exhaust

1. Have all exhaust from engines conducted to the outside by a properly installed manifold and exhaust system, which should be checked periodically to insure that it is in good operating condition and is free of leaks.

2. Make sure that the exhaust outside does not short-circuit back into buildings through open windows or ventilators.

3. Carefully investigate all pits and depressions in the building for accumulations of dangerous vapors.

4. Upon entering a building, immediately check for the presence of exhaust or other gases; use only approved test instruments and methods.*

5. Maintain ventilating equipment in good condition.

Repair

1. Be properly clothed for the job:

a. Never wear gloves, jewelry, neckties, long sleeves, or loose or torn clothing near machines with rotating or moving parts.

b. Keep hair clear of moving parts; wear a cap.

c. Keep shoes in good repair. Avoid rubber heels; use a nonslip material such as neoprene.

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* Consult "Mine Gases and Methods for Detection," Circular No. 33. US Bureau of Mines, Washington, D.C. (1948).

d. Have a complete change of work clothes available; wash them frequently and keep them separate from street clothes.

e. Do not wear oil- or gasoline-soaked clothing, even for a short time; do not place such articles in hot water for cleaning, because vapors may reach open flames and cause an explosion.

f. Do not, under any condition, use compressed air to clean work clothes.

2. Set up and follow a regular, tested procedure for maintenance and repair of engines.

3. Do not oil, adjust, or repair an engine while it is running or while its exhaust manifold is hot. Stop the motor and make sure that no one else can start it while work is being done.

4. Use a reasonably nontoxic, high-flashpoint solvent for cleaning engines and tools. (Kerosene, Stoddard solvents, petroleum naphthas, and methyl chloroform (1,1,1-trichlorethane) meet this requirement reasonably well.) Do not use gasoline, carbon tetrachloride, or other highly toxic cleaning agents.

5. Wipe machinery frequently and place the used cloths in covered metal containers until disposal. (See Sec. 17 for additional information on solvents.)

6. Do not smoke while working on an engine.

7. Either get help to raise heavy objects or use a chain hoist or other lifting equipment.

8. Secure heavy, unbolted engine parts if it becomes necessary to leave the work area.

9. Practice good housekeeping; keep the floor around engines clean, dry, and free of slippery materials and objects that may cause tripping; wipe up spillage immediately.

10. Use nonsparking tools where inflammable and explosive vapors may be present.

11. Open daily the drain valve at the bottom of compressed-air tanks, and, under pressure, blow off accumulations of oil, which are carried over from the lubrication of the compressor valves and which float on water that has condensed from the compressed air. This oil can vaporize and explode on being heated.

12. Know the location of an emergency shower for use if clothes catch fire.

13. Ascertain the location of fire extinguishers and be familiar with their use. (Periodic training for all employees in the use of fire extinguishers is recommended.)

14. Upon completion of repairs, thoroughly check the vicinity to insure that all tools, portable lamps, planks, ropes and other objects have been removed and that the cleanup has been carefully done. Before starting the engine, follow the recommendations presented in Sec. 18.

Section 19—Wells

Drilling

1. Inspect the proposed site to be sure that it is free of overhead or underground electrical hazards before moving in or setting up the drill rig.

2. Restrict the drilling area to authorized people only; do not allow the public closer than 50 ft.

3. Require the driller on each shift to make a thorough inspection before

the drilling operation is started in order to ascertain that all machinery and equipment, such as tools and cables, are in safe working condition.

4. Construct a suitable working platform at the drill hole and safely arrange the materials or tools that must be stored or used on the platform.

5. Substitute stranded steel cables for chains where possible.

6. Use stranded steel cable to lift the cap; never drive the casing while the cap is suspended from above.

7. Maintain all machinery clutches in good condition to insure that the release mechanism will function properly.

8. Install and maintain all necessary guards for mechanical power transmission.

9. Stop the engine while repairs are being made.

10. Permit only experienced personnel to work on the dynamiting of wells; always provide separate storage facilities for explosive caps and dynamite. (See Sec. 10 for additional information on explosives.)

11. Use safe practices in handling and storing gasoline on a drilling job; provide gasoline drums with spigots that can be locked.

12. Take adequate measures to prevent explosions and asphyxiations from subterranean gases; provide ample ventilation for all enclosures.

Housing

1. Where toxic or flammable gases are suspected or known to exist, provide ample positive ventilation in the building to assure the existence of a safe atmosphere at all times; keep the building securely locked, and permit only authorized persons to enter.

2. Collect well head gases and conduct them to the outside of the well house for liberation at an elevation above the roof.

3. Where flammable gases are encountered, use special nonspark electrical equipment. Enforce nonsmoking regulations; construct the well house with nonflammable materials.

4. If a question arises about the existence of toxic or inflammable gases in the well house, consult engineers of the state department of health, who have methods for testing the air for hazardous substances or for the lack of oxygen. (The common gases to be investigated are carbon dioxide, carbon monoxide, methane, and hydrogen sulfide.)

Section 20—Automobile Mechanics

The hazards involved in the maintenance, use, service, and repair of the automotive equipment of water works plants throughout the United States require the general application of safe working practices. Because a great deal of such apparatus is designed for specific automotive purposes, the following subsections deal with particular hazards and preventive measures that other industries have found effective.

Heavy-Duty Equipment

Follow these rules or precautions when working on, with, or around heavy equipment, such as dump trucks, backhoes, trenching machines, sidebooms, bulldozers, gas shovels, air compressors, and payloaders:

1. Place substantial blocking under any chain hoist–suspended or jack-supported equipment under which men must work. (The operator of trench-

ing equipment should never leave the controls while shovels are suspended without blocking.)

2. Be certain that feet are clear of passing automobiles or moving machinery when it is necessary to go beneath a car or other equipment; wear safety shoes.

3. Guard against inhaling excessive carbon monoxide gas from exhausts of running engines; provide proper ventilation.

4. Avoid keeping gasoline in open containers or pits.

5. Use Stoddard solvents or some other high-flashpoint solvent for cleaning parts; never use gasoline or carbon tetrachloride.

6. Use the recommended safety grip (thumb not around handle) when it is necessary to crank an engine by hand; crank heavier engines by a pull rope tied to the crank.

7. Get help to lift unusually heavy loads, or use a hoist.

8. Keep wrenches or other tools clean and in safe working condition.

9. Secure unbolted heavy parts or engines if it is necessary to leave the work place.

10. Keep goggles nearby and wear them when eye protection is needed.

11. Keep aisles and open spaces on floor free of tools and parts.

12. Change clothes that become soaked with oil or gasoline; do not risk a dangerous fire.

13. Check to make sure that all lock washers and cotter pins are in place before considering that the maintenance work is complete.

14. Always keep a suitable fire extinguisher at hand and ready for use; enforce existing no-smoking rules; inspect fire extinguishers regularly, and keep them in good operating order.

15. Be certain that electrical appliances are grounded and in good working condition and that sparking will not ignite gases or fumes in area; do not permit live cords to touch wet bodies or clothing or to touch workmen standing on wet surfaces.

16. Do not permit oily rags to remain lying about after use; put them in closed metal containers for disposal.

17. Review personal-protection stipulations for arc welders (see Sec. 21) before attempting such work.

Refueling Motor Vehicles

1. Stop the engine before fueling.

2. Avoid static sparks by inserting the hose nozzle firmly in the tank, making sure that metallic contact is made. Keep a hand on the nozzle throughout the entire delivery to prevent overflow.

3. Maintain tight connections on the hose and nozzle to eliminate all leaks.

4. Do not permit the tank to overflow.

5. Drain the hose before removing the nozzle.

6. Hang the nozzle securely, and see that the cap is placed tightly on the tank.

7. Change clothing immediately, if it is saturated with gasoline, to prevent possible burns or injury to the skin.

8. Use only Stoddard solvents or some other high flash-point solvent for cleaning purposes.

9. Prohibit smoking in the area when delivering or receiving gasoline.

Grease Pits and Hoists

In plants without pits or hoists, most of the following rules are applicable to areas where equipment is greased or oiled:

1. Keep floors, steps, or walkways free of spilled oil or grease.

2. Keep shoes free of oil and grease; do not wear shoes with rubber heels.

(Neoprene, or other nonslip substance, soles and heels are suitable.)

3. Keep under close control tools or other objects which might fall on or strike passers-by.

4. Keep hoses, cans, and other objects off driveways and walks.

5. Keep out of danger when guiding a car to a hoist or pit.

6. Do not allow anyone to remain in or near the car while it is being raised or lowered.

7. Never shoot the contents of a grease gun into the hand or point it at anyone.

8. Take all the time necessary to use tools correctly.

9. Clean tools daily with Stoddard solvents or other high-flashpoint solvents; use a wiping cloth frequently.

10. Keep a hand on the control valve while a car is being lowered or raised.

11. Make certain that the differential plate and the front-end plates will not strike an obstruction and that no one is endangered when the car is backed away; when the hoist is in a raised position insert a clearly visible safety bar or rod through fluted holes to prevent the hoist from descending.

Steam and Wash Rack

Many water works plants do not have elaborate areas or apparatus for steam or water cleaning of automotive equipment. The following rules generally apply, however, to both complete and temporary or makeshift means of truck and other vehicle cleaning:

1. Fill the coils to the proper level before turning on the flame in a steam cleaner.

2. Be certain that the nozzle outlet is unobstructed.

3. Check to see that the hose connections at the nozzle and the machine are secure.

4. Provide adequate heat insulation at the nozzle handle and along the portion of the steam hose touched by the operator.

5. Protect eyes and face with a face shield or goggles whenever practicable; wear moisture repellent clothing and footwear; check the ventilating system to make sure it is properly removing the fumes.

6. Carefully ground the noncurrent-carrying parts of a steam-cleaning machine.

7. Exercise great care in handling and preparing steam- or water-cleaning soap or compound to prevent caustic burns.

8. Provide oil-fired cleaners with fuel of sufficiently high flashpoint to prevent accumulations of volatile vapors.

9. Clean the firebox before ignition to prevent flarebacks.

10. Check the blowoff gage periodically for proper functioning; after the burner flame is turned off, keep the water supply on until coils are cooled off.

11. When the steam hose is not in use, secure it in its container.

12. Maintain a periodic inspection of steam hoses, especially where acute bends occur.

13. Prohibit horseplay in the area, especially with the steam-cleaning equipment.

14. Remove the coil cover before lighting the fire under the coil.

15. Use a low platform or portable scaffold, when practicable, to prevent slipping when car or truck tops and hoods are being washed or polished.

16. Watch out for sharp edges when using a sponge or chamois.

17. Do not use flammable solvents on the wash or steam racks.

18. Keep all oily or greasy rags in closed metal containers; practice good housekeeping in all other particulars.

Jacks

1. Always make sure that the footing is substantial and at right angles to the direction of lift.

2. Center the head to prevent its slipping out of place under load.

3. Protect hands, and particularly the knuckles, by placing the jack so that there will be a free, unobstructed swing of the handle.

4. Avoid leaning over a jack handle while it is under load. (If something should give way in the jack, the handle may fly up and cause injury.)

5. Remove jack handles from their sockets while jacks are under load so workmen will not fall over them or knock them out of position.

6. Secure all jack-lifted loads diagonally with braces or other supports to prevent the jacks from tipping over.

7. Install adequate blocking under all jack-lifted loads before attempting to work under them.

8. Use good judgment in selecting jacks for a particular job; choose only a jack that is safe and strong enough.

Chain Binders

1. When chain binders are used to secure a load, stand in such a position that they are pulled rather than pushed to apply tension on the handle.

2. Protect hands when a handle breaks over the center.

3. Do not extend the handle of a chain binder; use two binders if necessary.

4. Take defective binders out of service until they are repaired.

5. Place binders so that the handle does not extend beyond the edge of the truck.

6. Secure the handle in position with an approved fastener.

Truck and Car Tire Inflation

1. Always set the hand brake and turn off the motor before starting to inflate tires that are on the wheels of a vehicle.

2. Inspect tires thoroughly before inflating; take extra precautions if there are obvious weak spots in the casing; a blowout may cause blindness.

3. Know and use only the pressure recommended for the size and kind of tire.

4. Use a reliable pressure gage. (Rough handling can easily throw a gage out of adjustment, and in cold weather some do not work very well.)

5. When tires are inflated off the vehicle, lay them flat on the ground with the lock ring, if any, on the underside, keeping the head away from the side of the tire.

6. Where a considerable amount of tire inflation is required, consider the use of a cage of steel bars to prevent hurling of the lock ring when blowouts occur. (The bars are placed about 8 in. apart, and the air hose is inserted through them. One end of the cage is open for rolling the tire in.)

Willing Water Says:

A well planned program assures best results.

Oftentimes, the difference between good and bad tasting water is the correct dosage of AQUA NUCHAR activated carbon, applied at the right place. Using only enough AQUA NUCHAR activated carbon simply to reduce the threshold odor from 50 to 25 is not sufficient. Plant operators must constantly strive to deliver a palatable water — which means a Threshold Odor of 5 or less.

Thus, they will accomplish a distinct improvement which can be detected by even the layman. Consumers will also be appreciative, even though they may not say so, verbally.

To keep a constant check on the most efficient dosages required, as well as the most effective point of application, consult with our Threshold Odor Specialists. They will make a complete taste and odor survey of your water treatment plant, and explain to your chemist the procedures of the Threshold Odor Test. Another feature of their regular service will be to check, without obligation, the influences of other chemicals used and recommend how AQUA NUCHAR activated carbon may best be employed.

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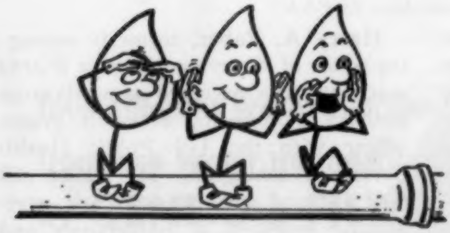

Percolation and Runoff

The heat is on! And at the end of the hottest July in the Northeast's history, beginning an August that is already angling for a record of its own, we're all for an off of it. Not just we, either, for right across the river in northern New Jersey there is talk of imminent catastrophe if the hot weather continues and the rains, which were all but absent in July, do not show up in August. Elsewhere over the nation, too, the usual hot-weather worries are being aggravated not only by more heat and less rain, but by more customers who want more water than ever before.

In Jersey something more than just "talk" is actually being done about the situation, but so far the action has been almost all negative—aimed at reducing consumption rather than increasing supply. The positive program, meanwhile, has been backwatered by bickering state legislators, reluctant not only to pay for the reservoir all agree to be necessary, but to accept any site that will flood out any of their own constituents. Best solution at the moment seems to be a site in neighboring New York or Pennsylvania, which seems just about as likely as general agreement on anything practical. Meanwhile, too, nearby New York City, luxuriating in its new Delaware supply to the extent of boosting consumption to record highs of more than 1.3 bgd, is hardly the kind of company that misery loves. Even carefree New York is beginning to be a little concerned, however—not about supply, but about the delivery capacity to meet the unprecedented demand.

Down in Texas the problem seems no less acute, although more appears to have been done about it for some time. At Dallas, for instance, the water department has been able to keep pace with the 58 per cent increase in demand during the past 5 years by spending $7,500,000 per year to expand distribution facilities; and now the city is looking forward to more than quintupling capacity by the year 2000. Not just locally, either, but in district and regional organizations, Texans have been thinking and working hard at availabling a larger proportion of the state's rainfall, which now averages 30 in. per year on the rain gages and 4 in. per year on the water meters. And even if the Texas legislature, too, booted its big opportunity in failing to come up with the enabling legislation for a $100,000,000 bond issue to help communities underwrite the cost of dams and other water supply works, it did put through 59 other laws relating to water supply.

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Nationally, too, our legislators are beginning to spend a little more time and thought—and money—on water supply problems. Biggest indication was the approval in July of the largest program in the nation's history to investigate water supplies—an appropriation of $4,350,000 as the federal share of a matching-funds program. But the strong support of a bill authorizing 5-year tax write-offs for water purification plants is another sign of the happier times. The write-off bill, of course, is aimed specifically at helping industry pay for its wastes purification plants, but the secondary benefit to water works can certainly be significant.

When the heat is on, however—as it most certainly is right now—the heat is really on the water works man himself and, though he may thank the state and federal governments for small favors, the problem of providing for his customers is still his own. Which gets him into no lack of hot water anyway.

Sanitary engineer registration is being undertaken by the US Public Health Service, at the request of the Office of Defense Mobilization. The "National Register of Engineers" will make available information on trained technical and scientific personnel who might be needed in time of war or disaster. A one-page questionnaire which requires only a few minutes to fill out has been prepared in cooperation with Engineers Joint Council and the National Science Foundation. The questionnaire will be mailed to a list of more than 10,000 engineers, compiled from professional-association membership records and other sources. When completed, the register will be maintained by the Public Health Service.

Harry A. Faber, formerly managing editor of *Water and Sewage Works* magazine, has accepted a position as sanitary engineering research grants officer with the US Public Health Service, Washington. Mr. Faber will appraise and evaluate sanitary engineering research at universities and other institutions throughout the United States, determine areas of need, and recommend methods for strengthening research efforts by grants and other means. In this capacity, Mr. Faber will work closely with the National Institutes of Health, the Robert A. Taft Sanitary Engineering Center, and other Public Health Service agencies interested in sanitary engineering research.

The bath as a measure of our standard of living had no sooner been discussed in these columns last May (P&R p. 36) than our friends in West Germany were obliging enough to underline our point almost violently. Their strong feelings on the subject were aroused when the West German Society for Bathing Facilities, after a survey, announced that 30 per cent of all German houses had no tubs. To this "shameful exposure" the public objected immediately and vociferously, complaining that it pictured the Germans as an unwashed people. Not to air their dirty 30 in public, then, the society turned to a campaign for more washbasins in schools and factories, hoping thus, a little more subtly, to make available to the tubless ample facilities for washing during the day. But a tub in every home remains the society's and the public's obreptitious objective.

At the same time, in Sweden, where the standards of both living and bathing are on a par with our own, the

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relationship has been carried even one step further. Recognized throughout the world for the progressiveness of its social legislation, particularly as it applies to the aged and the infirm, Sweden has now taken that same solicitude right into the bathroom with the development of a special bathtub for its elders. Designed to obviate the high step in and out and to reduce the danger of slipping, the tub has a side door, the bottom of which is flush with the bottom of the tub. Two easily manipulated handles compress the door against a gasket around the frame to provide a watertight seal during use. Thus, not just a tub for every home or every bedroom, but the proper tub for each.

Here in the US, meanwhile, the TPC (tubs per capita) principle seems momentarily to have been twisted around to CPT, the "C" in the "T" being Marilyn Monroe, whose bubble bath in the film version of *The Seven Year Itch* will probably do considerably more for the bathtub than will our theory. Lest you be confused, neither her story nor her bath has anything to do with schistosomiasis—nor, unfortunately, with our standard of living.

Robert J. Koll has been named manager of the Diamond Alkali Co. Greens Bayou Plant at Houston, Tex. Mr. Koll has been with the company since 1945.

General Filter Co. has opened its new office building at 925 Second St., Ames, Iowa.

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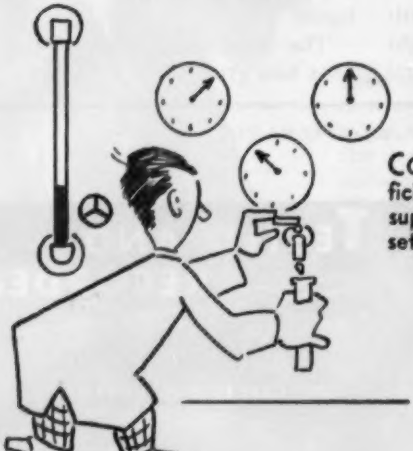
ONE
WAY




FORD


FORD

(Continued from page 38 P&R)

Walter W. Land: The American Water Works Assn. lost a valued counselor, and the officers and staff a wise friend, by the death of Walter Land, the Association's legal advisor for more than 10 years. His death on Jul. 23, at the age of 46, brought to an end a long period of patient suffering and courageous resistance to the inroads of cancer.

A native of the State of Washington, son of a Congregational minister (still living), a graduate of the University of Colorado and of Columbia University, Land maintained a scholarly attitude throughout his career. He taught in law school and served for several years as a member of the House of Delegates of the American Bar Assn.

In his home community—Port Washington, N.Y.—Land was active in civic affairs. He was a county Republican committeeman and attorney for the Port Washington Water Dist.

As legal advisor to AWWA, his counsel was always well tempered and wise. He could be characterized as an attorney who advised conference rather than litigation, who supported strongly the legal position of his client but preferred the development of mutual understanding to a courtroom battle.

The Association and its staff will miss him greatly.

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Stopping
Corrosion

(Continued from page 40 P&R)

E. B. Cottingham has been elected president of Henry Pratt Co., Chicago. Formerly vice-president in charge of production, Mr. Cottingham succeeds S. B. Smith, who becomes chairman of the board. Other company officers include A. C. Johnson, secretary and treasurer; W. T. Herren, vice-president—construction; and W. J. Woolley, vice-president—sales.

Well oiled and definitely in need of a water wagon these days are the villages of Fredonia, Ky., and Medora, Ill. Both communities, in need of water works, hired well drillers. Both well drillers struck oil—Al Taylor at 235 ft in Fredonia, A. R. Frank at 332 ft in Medora. And, given a second chance, Frank could do no better than uranium ore. At Fredonia a small-scale oil boom is in progress—meaning more thirst to quench. At Medora, the situation is apparently classified. "Happy," anyway, should be the word for both, for to be well oiled is to be well heeled should be to be well watered.

Water utility safety will be one of the topics discussed at the National Safety Congress in Chicago next month (see "Coming Meetings," p. 8 P&R). Scheduled speakers at the water utilities session, Thursday afternoon, Oct. 20, include: Wendell R. LaDue, chief engineer and superintendent, Bureau of Water & Sewerage, Akron, Ohio; Thomas Allen, safety engineer, Dept. of Water & Sewers, Chicago; and Milton Bowman, safety director, Cleveland, Ohio. Oscar Gullans, chief fil-

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tration chemist, Bureau of Water, Chicago, is listed as the discussion leader, and James E. Hickman, safety engineer, Dept. of Water & Power, Los Angeles, will preside.

Fire Prevention Week is almost here again—and again it is a week which water works, too, can profitably observe. Looking to your own fire prevention measures is one way, and an important one. But you can also make it your week by telling your public about your hydrant installation and maintenance policies, by providing information on what percentage of your facilities and how much, or little, of your water are required for fire protection, and by discussing the relation of the water system to fire insurance premiums. Every week is public relations week, but the week of Oct. 9–15 can be a special one!

Robert M. Dixon, managing director of the Municipal Contractors Assn., Dallas, has been appointed to a 6-year term on the Texas Board of Water Engineers and became chairman effective Aug. 19, 1955.

Ben S. Morrow has retired as chief engineer and general manager of the Portland, Ore., Bureau of Water Works, terminating a career of 46 years with the bureau, the last 30 as its head. He is succeeded as chief engineer by H. Kenneth Anderson, chief civil engineer of the bureau since 1950. Commissioner of Public Utilities Nate Boody will function as general manager, at least temporarily.

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A hose dive in Downey, Calif., last July started a nationwide vermiculation that has every owner of a plastic garden hose locking it up in his attic when it is not in use. Leading the movement underground was a ½-in. green plastic "job" with which George Di Peso's daughter was watering her garden one evening. Having stuck the hose nose into the ground for a moment, she found that she could not pull it out—and, then, as she became concerned, that it seemed to be worming its way deeper into the ground. Several days and 13 ft later, the Di Pesos found themselves world celebrities whose every move to exhume their refractory water line rated front-page headlines. By the time every one of hundreds of guests had tried his hand and muscle at the task, by the time the family car in low gear had failed to regain an inch of hose, by the time it had hauled the sill cock almost out of the wall, Mr. Di Peso was fed up with both the hose and the publicity. He put an end to both by snipping the line off at ground level and letting it go to—well, wherever it was headed. Meanwhile, either envious of the attention or acting under the same compulsion, other hoses elsewhere began to follow the one from Downey down:

At nearby Norwalk, Calif., Calvin Barham stuck his hose 2 in. into the ground to water the roots of a tree. One hour later 2 ft of hose had disappeared and, by the following morning, 5 ft had engrounded. Barham got to the bottom of it all with a shovel, recovering his truant tube from soft, but by no means quick, sand.

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The Reading Meter

Water Supply Engineering. *Harold E. Babbitt & James J. Doland. McGraw-Hill Book Co., 330 W. 42nd St., New York 36, N.Y. (5th ed., 1955) 608 pp.; $8.50*

The fifth edition of this well known text and reference work differs from the fourth probably more than any earlier edition differed from its immediate predecessor. The inclusion of new information on the latest water works practices has been accomplished without increasing the length of the book, thus forcing the deletion of some older material. Emphasis is placed on design, with information given on financing, operation, and management primarily as they may affect design. The applicability of the book to advanced study has been improved by numerous references to source material. Many new tables and illustrations have been employed, and the appendix of problems has been revised.

Soft Water in Modern Use. *Water Conditioning Research Council, 111 W. Washington St., Chicago 2, Ill. (1955) 42 pp.; spiral bound; $2.50*

Designed to present the advantages of soft water to the public, this booklet discusses the functional, economic, health, and other aspects of the subject in terms understandable to the layman. A number of tables and maps are included, most of the data contained being familiar to water works men.

Gewerbliche und Industrielle Abwasser. *Friedrich Sierp. Springer-Verlag, Riechpietschufer 20, Berlin W 35, Germany (1953) 555 pp.; DM 49.50 (approx. $11.80 US)*

The effects of industrial wastes upon sewage treatment plants and receiving streams are discussed in this German-language work, but the bulk of the book is devoted to specific wastes and the ways in which they may be treated. Over 40 specific industries and countless waste products are discussed in detail.

Steel Structures Painting Manual. *Vol. 2, Systems and Specifications. Joseph Bigos, ed. Steel Structures Painting Council, 4400—5th Ave., Pittsburgh 13, Pa. (1955) 292 pp.; $6 ($5 to AWWA members)*

The specific recommendations in this book are a supplement to the general recommendations in Vol. 1 (see February 1954 JOURNAL, p. 46 P&R). Surface preparation, pretreatment, paint application, paints, and complete paint systems are covered. The book takes cognizance of applicable standards of AWWA, which is represented on the Painting Council. A useful index and guide to the selection of systems for different conditions is included.

Municipal Index—1955. *American City Magazine Corp., 470—4th Ave., New York 16, N.Y. (1955) 1,101 pp. (including advertising); $10*

The 29th edition of this annual purchasing guide for municipal officials is about 80 pages larger than its predecessor. As usual, it contains an up-to-date roster of town and county managers and a list of department heads (including wa-

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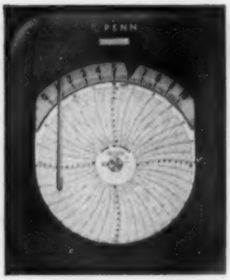

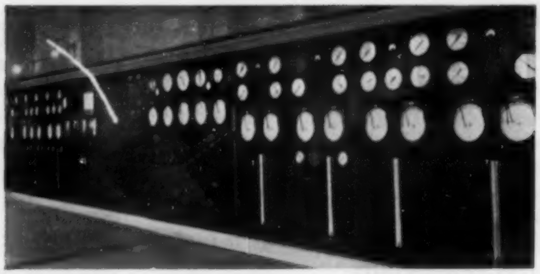

The Reading Meter

(Continued from page 48 P&R)

ter and sewage works superintendents) in cities of 10,000 population or more. The book also contains useful and informative sections on municipal trends and suppliers of materials and equipment. The bound-in atlas, which furnishes maps and 1950 population statistics, has been improved in readability.

The Chemical Industry Facts Book. *Manufacturing Chemists' Assn., 1625 I St., N.W., Washington 6, D.C. (2nd ed., 1955) 160 pp.; paperbound; $1*

This well illustrated book contains fifteen chapters briefly covering the operations of the chemical industry and its products and their applications. The present volume is 52 pages larger than the first (1953) edition, including such features as a list of trade associations and professional societies identified with chemical manufacturing. The book should prove a useful source of statistics and other general reference data on the industry. A teacher's guide for use with the book is available free to educators.

Water Treatment Handbook. *Etablissements Emile Degrémont, Box 46, Surèsnes, France; English edition available from Hugh K. Elliott, 20 Harrington Court, London, S.W. 7, England (1st English ed., 1955) 468 pp.; $7.70 US*

This well illustrated handbook packs a great deal of information and tabular data on the various aspects of water treatment into its more than 400 4½ × 7-in. pages. It covers such subjects as water chem-

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The Reading Meter

(*Continued from page 50 P&R*)

istry, coagulation and filtration, chemical feeding, softening, disinfection, and boiler and swimming pool water treatment. Its usefulness is somewhat lessened by the (necessarily) small type and the perhaps excessive references to proprietary equipment.

Directory of Commercial and College Testing Laboratories. *American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. (1955) 40 pp.; paperbound; $1.00*

This directory supersedes US Dept. of Commerce, National Bureau of Standards Miscellaneous Publication M187. It lists commercial and college testing laboratories that will test commodities for acceptance or other purposes, in accordance with standard specifications. Consulting and industrial research laboratories have been listed only if it is definitely known that they are also engaged in testing on a commercial basis.

Surface Water Resources of Georgia During the Drought of 1954. *Part 1, Stream Flow. M. T. Thomson & R. F. Carter. State Div. of Conservation, Dept. of Mines, Mining, and Geology, 425 State Capitol, Atlanta, Ga. (1955) 80 pp.; paperbound; free*

This report contains stream flow data collected by the US Geological Survey in Georgia during the 1954 drought for the study of minimum flows. Part 2 of the report (in preparation) will analyze these data and present derived values of drought flows and storage needs for unregulated streams.


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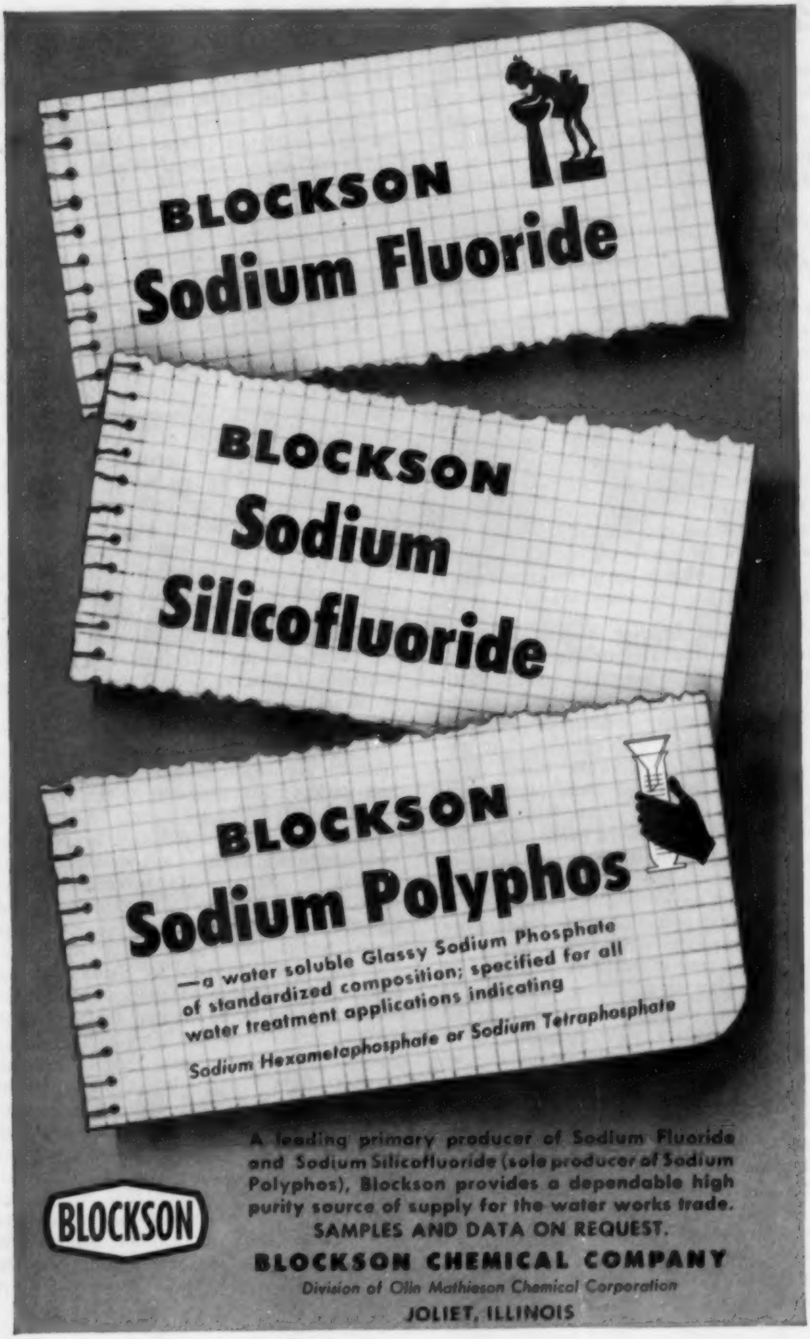
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Key: In the reference to the publication in which the abstracted article appears, 39:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, 39:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: ***BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).***

DISINFECTION

Preliminary Investigations With a "Sterilit" Experimental Filter Used for Drinking-Water Disinfection. II. J. F. Braune. Gesundh-Ing. (Ger.), **75**:15 ('54). Silvered granular filtering material previously tested on lab. scale under artificial conditions proved successful when tested for 9-month period on natural hard water having bact. count occasionally ranging over 10^4/ml. *Escherichia coli* reduced from peaks of 500/100 ml to less than 100/100 ml. App. of 10-l capacity was used, and disinfecting effect was rapid and lasting. Contact time of at least 4 min, removal of flocculant and org. material prior to treatment, and regular backwashing are recommended.—*CA*

Bacteriological Studies on the Effect of Chlorine for the Disinfection of Water. L. Popp. Gas- u. Wasserfach (Ger.), **95**:100 ('54). Surviving organisms were counted 12 sec–60 min after mixing of organisms (mostly *Esch. coli*) with chlorine. At same time free available chlorine (after 30-sec contact) and combined available chlorine (after 5-min contact) was detd. with *o*-tolidine. Many tests were made using chlorine contents up to 0.6 ppm from various chlorine sources and at different pH and bact. loads up to 10^8 organisms per ml. It was found that reduction of organisms does not follow exponential law but occurs in two steps. First step is rapid reduction of organisms, lasting about 12 sec, and is called primary drop in organisms. This is followed by secondary slow reduction of organisms. These two steps are independent of source of chlorine but first step is more marked if high-chlorine soln. is used relative to no. of organisms and also if chlorine is added to suspension rather than suspension to chlorine soln. Primary drop in organisms is also greater at low pH, between pH 7.5 and pH 10 it is small. Killing action of chlorine is used up during initial contact period. Reinfection causes only small primary drop in organisms. Free available chlorine detd. after 30 sec of adding *o*-tolidine is measure of bacterial killing power, which 5-min reading does not give. In tests with water contg. 1 ml/l sterile milk, 2-ppm chlorine dosage reduced free available chlorine in 30 min to 0.15 ppm. Injected at that time chlorine has little killing power. Tentative explanations are: In primary drop of organisms there is exponential function of monomolecular action of HOCl molecules in *statu nascendi*. Later-formed combined available chlorine is less active and slower. Chlorine has to contact critical part of bact. body. Much of chlorine may form protective layer as later addn. of chlorine do not produce strong primary drop. Similar tests should be made in other labs.—*M. Suter*

Experiments on the Disinfection of Drinking Water with Ultraviolet Light. B. Schmidt, I. Moller & W. Thiele. Z. Hyg. u. Infektionskr. (Ger.), **139**:505 ('54). Many communities in Germany are not yet provided with bact. pure water and fact that German population does not readily accustom itself to use of water which has been chlorinated (in places where chlorination is practiced, it is not followed by any possibly needful method of dechlorination) renders it desirable to investigate other methods of sterilization. In expt. described, 2 types of mercury vapor quartz lamps were tested for bactericidal efficiency: "Stevar" appliance made by Swiss firm and quartz lamp made by Hanau company. In former, water to be treated flows through app. at velocity of 500 l/hr, and in latter water remains in quiescent contact with ultraviolet light for 5 min. General results were that both lamps were efficient with artificially polld. clear water but not with polld. natural river water. Examn. of river water showed that thickness of 1.0 cm allowed penetration of only 30% of rays of wave length of about 254 mμ, which are most bactericidal. It follows that waters to be sterilized by ultraviolet light must be adequately clarified before exposure.—*PHEA*

(*Continued on page 64*)

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Experiments on the Quantitative Determination of the Lethal Activity of Chlorine and Ozone on *Esch. coli*. G. Bringmann. Z. Hyg. u. Infektionskr. (Ger.), **139**:2:130 ('54). In order to study action of chlorine on *Esch. coli* under controlled and constant conditions, washed organisms were suspended in 1 l of phosphate buffer, and viable counts of this suspension were made at intervals after addn. of chlorine. Effects of chlorine concn., bact. concn. and temp. were studied; observations were also made on diminution of free chlorine content resulting from combination with bacteria; results presented graphically. In similar expts. with ozone, bacteria were killed so rapidly that process could not be followed in same way. It is suggested ozone must have mode of action different from, and less specific in its combining site than, that of chlorine.—*BH*

The Effects of Ultraviolet Irradiation on Large Populations of Certain Waterborne Bacteria in Motion. II. Some Physical Factors Affecting the Effectiveness of Germicidal Ultraviolet Irradiation. J. R. Cortelyou et al. Appl. Microbiol., **2**:269 (Sep. '54). Paper is concerned chiefly with investigation of germicidal efficiency of General Electric Co. G4T4/1 lamp when employed in unit previously described by same authors. Broth suspensions of *Esch. coli* were used to inoculate water samples; in 70% of samples treated, counts were in excess of 1,000,000 organisms/100 ml. In all, 201 contamd. water samples were irradiated with varying intensities and it was found that sterilization was achieved with ultraviolet light intensities of at least 650 mw/sq ft at 2⅞" in air from lamp center. Such factors as ambient temp. and voltage fluctuations cause reduction of intensity, but quartz enclosure surrounding ultraviolet lamp markedly decreases temp. effects on output. Available intensity of ultraviolet light is affected by transmitting medium, and waters have differing absorption factors depending upon their qual. Effect of age of lamp is also discussed; natural decrease in lamp in-

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tensity will occur as function of burning time.—*BH*

Disinfection of Water by Solid Compounds of Hydrogen Peroxide. M. POLSTER & Z. BOCHORAK. Ceskoslov. Hyg., Epidemiol., Mikrobiol., Imunol. (Czech.), **3**: 291 ('54). Owing to difficulties met when using H_2O_2, addn. salts (**I**) of H_2O_2 with Na carbonate were tested. They caused min. denaturation of water, were easy to apply, and were not poisonous. To achieve perfect effect, however, comparatively large quant. of **I** and long period of contact are necessary; salts have limited stability. Efficiency of **I** is enhanced by Ag salts and stability by silica gel.—*CA*

Disinfection of Water by Ozone. H. GUBELMANN & H. SCHELLER. Monatsbull. Schweiz. Ver. Gas- u. Wasserfachm. (Switz.), **33**:53, 99 ('53). Authors discuss literature on exptl. and practical use of ozone in disinfection of water, illustrating discussion with diagrams of various plants and of plant at Martikenfelde used in expts. 2 forms of app. for adding ozone to water were used in expts.: contact tower in which ozonized air was passed, in counter current to water, at pressure of about ½ atm., and pressure chamber into which ozonized air was blown at pressure of about 1 atm. Results of bact. investigations, amts. of ozone required, and costs of ozone production at different plants are discussed. Authors' expts. were on tech. scale, using 2,642–7,878 gph of water; same spring water was used throughout. Expts. were planned to det. amt. of ozone required to ensure a bact. satisfactory water, to detd. best process of production of ozone and of mixing ozone and water, and to exam. costs of process. Yield of ozone from air varies with moisture content of air if this exceeds 1 g water/kg air. Moisture can be removed by absorptive materials, by supercooling, or by compression. Authors used supercooling to reduce moisture to about 0.13 g/kg. Recently designed plant intended to avoid necessity for drying air is described and discussed. General design of

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plant for production of ozone is described and voltage and frequency of required alternating current are discussed; figures are given of power requirements of different existing plants. Data are given on soly. of ozone in water and methods of obtaining highest possible transfer of ozone from air to water are discussed. Effects of mixing by contact tower, pressure chamber, and indirect systems, by which part of the water is ozonized to relatively high concn. and then added to main flow, are discussed and illustrated by diagrams. Costs of ozone production, air drying, and mixing are given. Results of expts. show important effect of qual. of water; most unfavorable results were obtained when raw water contained sludge. Bacteria remaining after treatment were harmless resistant types of spores naturally present in original water. For water used, it was found that plant producing 1 g ozone/cu m water would be sufficient to give margin of safety; on yearly avg, water, if filtered before treatment, would not require more than 0.5–0.6 g/cu m. Ozone production without air drying was found uneconomic. Total cost of construction, equipment and operation are calcd. for several types of plant. Costs varied from 356 Swiss francs to 606 Swiss francs/ozone/hr in commercial systems with yields of 500 g and 1,000 g/hr. In discussion, experiences from several other supply and exptl. plants were given.—*WPA*

Bactericidal Studies of Chlorine. R. S. Ingols et al. Ind. Eng. Chem., **45**:996 ('53). Studies made to det. nature of oxidation product of cysteine and other common amino acids with hypochlorous acid, monochloramine, and chlorine dioxide and to evaluate the importance of the various mechanisms in bactericidal effects of chlorine compounds in disinfection of water. It appears that effectiveness of hypochlorous acid and chlorine dioxide as bactericidal agents is due to irreversible reaction with sulphydryl radical of bact. enzymes. Monochloramine is less effective disinfectant, requiring higher residual concn. and longer period of contact for complete destruction

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of bacteria, as it does not immediately oxidize sulphydryl radical to irreversible form. It is suggested that failure of cysteine to restore bact. activity is due to changes in bact. enzyme systems other than sulphydryl group.—*WPA*

The Penetration of Ultraviolet Radiation and Its Effects in Waters. R. C. Hoather. J. Inst. Water. Engrs., **9**:191 ('55). Ultraviolet radiation was used on different depths of water, and the results of action on coli-aerogenes was studied. Effect of natural ultraviolet radiation on microscopic forms of life was also considered. Efficiency of lamp varies with qual. of water and distance. With app. at present available, cost seems too high and would compare unfavorably with chlorination, but advantages may be considered in appropriate circumstances.—*CA*

AQUATIC ORGANISMS

The Importance of Algae to Waterworks Engineers. J. W. C. Lund. J. Inst. Wtr. Engrs. (Br.), **8**:497 ('54). Richness in algae of reservoir or lake could generally be related to surface geology of catchment area and land utilization. Water rich in plant nutrients, such as sewage, favors prolific growth of algae. These broad principles were known 25 yr ago, when Freshwater Biol. Assn. was formed, and progress since then has consisted of increases in detailed knowledge. Many factors concerned, and their correlation with time, are considered, reservoirs may alter with age, and effect of aging may result in troublesome algal growths. 3 main changes occur, separated by long or short periods. Algae may become abundant and species may change. Lower layers of water and mud remain aerobic. Lower layers may become periodically anaerobic, when thermal stratification exists, as in summer, or under ice in winter. Algae become abundant, as in Lake Windemere. Higher degree of anaerobiosis during thermal stratification period leads to permanently stratified water by making deepest soln. so concd. as not to mix with water—chemically produced density

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change. In this stage, algal blooms are frequent and often offensive, as in Lake Zurich, Switzerland. Causes of algal production: Production is directly related to nutrient supply. Phosphate concn. shows no variability which can be related to rise and fall of large algal growths, but addition of phosphatic fertilizer alone is often followed by increase in algae. Possible explanations: when phosphate is added, equivalent amount of positive ions also added—usually calcium; addn. of phosphorus has indirect effect—due to interaction with substances or other organisms; addn. of phosphate leads to changes in algal flora; effect of increase in phosphorus may be due to adsorption on colloids in surface deposits, thus forming an equil. with that in soln. In deep water, amt. of illumination limits growth—algae grow in illuminated margins. Shallow water has larger area, and turbulence results in disturbance of surface deposits. Projected survey of British flora of fresh-water algae and its practical use in enabling plankton changes in reservoirs to be recorded is mentioned. Utilization of nitrogen: Similar arguments prevail for nitrogen and other essential nutrients. Blue-green algae are often troublesome as "blooms," especially in summer and early autumn. These often have distinctive odors and tastes. During growth, inorganic nitrogen is often present only in small amts. but cells have more nitrogen than other types. From pure culture work in inorg. solns., nitrogen fixation appears unlikely, growth needing a nitrate supply and high pH. It is suggested that when blooms are produced, they are not actively growing, and may exist for prolonged periods in light under conditions of nitrogen starvation. Another possibility may be that bacteria in algal sheaths transform atmospheric or organic nitrogen for algae. Big blooms may be due not to growth, but to sp. gr. of algae which rise to surface due to gas vacuoles. This is supported by bloom destruction by wind. High pH values due to photosynthesis may also lead to

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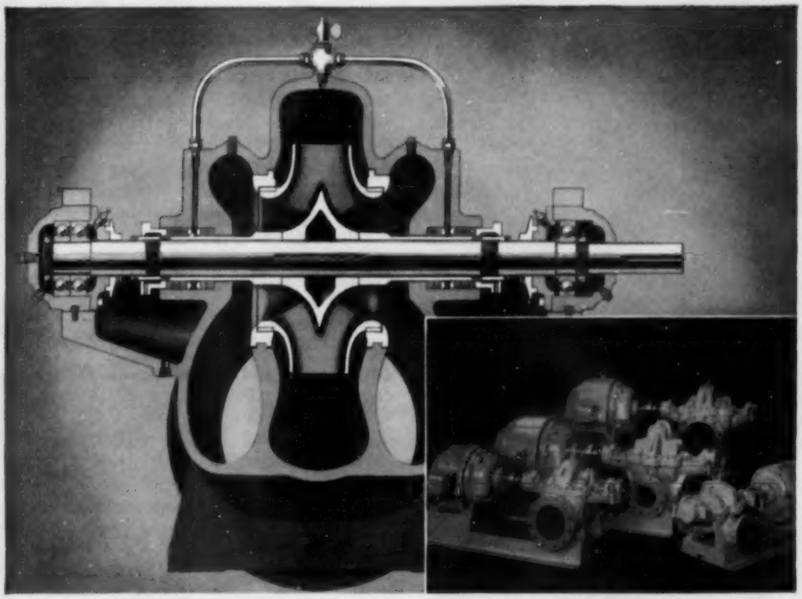

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(*Continued from page 72*)

mass destruction, causing taste and odor in water. Other nutrients: Various inorganic nutrients, including trace elements, are now being studied at Freshwater Biol. Assn. Most algae photosynthesize and do not require org. compds. for energy supply, but may need minute amts. for metabolic processes. Sewage is rich in such remnants of bact. or fungal decomposition. Control of algal growths: State of reservoir will only alter if water entering it alters. Large inflow determines nature of deposits and algae. Deterioration in Swiss lakes is largely related to human activities. Windemere is unsuitable as reservoir because of undesirable changes which have been occurring in last 25 yr. Ideal site for reservoir is in mountains, provided conditions are not too calcareous; it should be large and deep. If only lowland sites are available, those with poor soils in catchment area should be selected. Depth area should not be big enough to allow thermal stratification, but not small enough to encourage algal growth. If this is not possible, retention times should be as short as possible, or treatment plants should be set up to deal with algal growth. Algal growth, however, rarely exceeds 2 divisions/day. It is suggested that mechanical shading may be used to control algal growth. Another useful line of investigation is mentioned—control by organic and metalo-organic compds. Results of Fitzgerald and Skoog in this field are referred to toxic effects of 2-3 dichloronaphthoquinone in certain concns. on blue-green types.—*PHEA*

Studies of the Viability of *Histoplasma capsulatum* in Tap Water. C. Ritter. Am. J. Pub. Health, **44**:1299 ('54). Expts. have been made to study viability of *Histoplasma capsulatum* in sterilized tap water stored at temps. corresponding to water temps. in nature. Survival was demonstrated by cultural means and confirmed by animal inoculation in water inoculated with yeast phase and stored at 4°C for

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621 days and at 20°C for 550 days. Survival was demonstrated by cultural means after 306 days at 25°C, 95 days at 34°C, and 62 days at 37°C. No viable cells were recovered after 3 days at 45°C. Survival after 421 days was demonstrated by cultural means in water inoculated with mycelial phase and stored at 4°C; after 217 days at 20°C; 245 days at 25°C and 34°C; and 269 days at 37°C. There was no survival after 3 days at 45°C. Quant. counts of colonies developing on artificial media are higher from water held at 20°C and 25°C than at other temps. *H. capsulatum* has been shown to survive alternate freezing and thawing for 198 days, and to survive in triple-distilled water for 28 days. Evidence of conversion from yeast to mycelial phase and of growth of mycelial phase in water is presented.—*PHEA*

Effect of Standard Water Purification Processes on the Removal of *Histoplasma capsulatum* From Water. D. F. Metzler, C. Ritter & R. L. Culp. Am. J. Pub. Health, **44**:1305 ('54). Processes of coagulation and sedimentation, rapid sand filtration, and chlorination as practiced in treatment plants for surface waters have been applied in laboratory to samples of river water or tap water sterilized and inoculated with mycelial phase of *H. capsulatum*. Sedimentation experiments showed that settling of either natural turbidity in water or floc produced by coagulation with alum concentrated majority of spores in sediment. Model rapid sand filter did not effect complete removal of either yeast or mycelial phase of *H. capsulatum* suspended in tap water. There was little difference in removal, whether using 3″, 12″, 24″, or 30″ of sand. Under conditions of these expts., more free available chlorine residual was required in water to inactivate *H. capsulatum* in mycelial phase than to destroy enteric bacteria or virus of poliomyelitis under similar conditions. Complete kill of original inoculum producing approx. 950 colonies per 0.5 ml was demonstrated with 0.35 ppm free chlorine at 6-hr contact or with 1.8 ppm at 60-min. Interpolation of exptal. results indicated minimum effective contact times at these residuals of 4 hr and 35 min, resp.—*PHEA*

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At another end of Downey, Calif., Mrs. Robert Breeze stuck a hose in a hole to drown a gopher and returned later to find 15 ft of it inhumed. Unable to haul it out with the aid of three of her neighbors, she decided to give the devil his due by chopping the line off at ground level and filling the hole.

At Proctor, Minn., Robert A. Wombacher revealed that 15 of of the 50 ft of garden hose he had left on the lawn one Tuesday had disappeared into the ground by Saturday when he next needed it. Attributing his loss to the fact that the ground around the house was "mostly fill," Mr. Wombacher apparently let it go at that.

Two weeks later in the Queens section of New York City, a 100-ft plastic hose apparently tried to make up for lost time by taking its dive at the rate of 25 ft in less than 10 hr. There, a 222-lb neighbor, who failed to recover it with all his might, set up his cot at the spot to await the return of "pretty surprised" Patrolman Harold Smith, owner of the hose and the property into which it wormed.

Of course there is an explanation to this hose play; as a matter of fact there are many, perhaps the most elaborate of which is that extended by a correspondent of the Newark, N.J., *Evening News,* who pointed out:

The mystery of the disappearing water hose in the ground is explained by the elements going into the plastic hose, i.e., cellulose.

Cellulose is the substance which composes the greater part of the cell walls of plants. When dry it soaks up water

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readily until it is saturated. In other words, it is the element which attracts the water to the plants or pulls the plants —through its roots—to water.

When we consider cellulose is derived from coniferous trees, such as spruce, hemlock, also other plants such as cotton, and that a hemlock branch is effective as a dowser, divining rod, or means to locate wells, we have the pull of a hemlock twig over a deposit of water greatly multiplied in the concentrated cellulose or plastic hose.

The inherent properties of the plant cellulose to bring the roots of a plant where there is water seemingly remains throughout the process of being formed into plastic, and we have the plastic hose made of a good percentage of the cellulose of hemlock—without the nozzle—working itself through the earth, even as the roots of a plant, to get to a deposit of water.

Others, less divine or dowsy, have tended to be a little more offhand in their speculation about the hosiery. Granting that a hose may have a genuine desire to help conserve public water supply by seeking its own auxiliary source, they have been unwilling to credit it with such strength of that purpose as is indicated by the backbreaking reports. More likely, they feel, this is the hose's own answer to the competition of the underground sprinking system or, perhaps, just an escape mechanism worthy of an especially hot and dry summer. At any rate, it has been a relief to hear that these dives have been as waterless as they have been groundless, the water, in each case, having been shut off before or just after the hose netherealized.

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Every dog has his day when his family shops at Wallachs, and for a very good reason: water, of course, the world's best drink, not only for dogs and dog's days, but for the dog days as well (see photo). As a matter of fact, there have been days in the immediate past when, walking along Fifth Avenue, we've wanted to cool our own dogs at Wallachs' bar and had to settle for trying on shoes in the air-conditioned inside. It is a dog's life!

[If the photo of the barhound on his first lap seems just a little off our season, just remember that August is the month when Wallachs and other New York stores hold their fall clothing sales. When else but during the dog days would they be lined up like that?]

Helen Rotthaus, former Arizona Section secretary, has been given a large share of the credit for the smooth operation of that state's polio vaccine program. As clerical supervisor and secretary to the Arizona commissioner of public health, Mrs. Rotthaus established schedules, arranged for transportation, and provided public education material. With the close assistance of personnel from the health department and other agencies, she was able to coordinate the activities of the numerous groups whose participation was essential to the success of the program.

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Leland G. Carlton, former superintendent of the Springfield, Mass., Water Dept., died Jun. 11 at the age of 70. Born at Brattleboro, Vt., he held a degree in civil engineering from the University of Vermont. Mr. Carlton, who joined the Springfield Water Dept. in 1906, became its superintendent in 1940, a position from which he retired last year. He was past-president of the New England Water Works Assn. and of the Engineering Society of Western Massachusetts. He had been an AWWA member since 1941.

Rollin F. MacDowell, head of the consulting sanitary engineering firm of Rollin F. MacDowell & Assocs., Cleveland, Ohio, died at the age of 69 at his home May 25. Born at Columbus, Ohio, Mr. MacDowell became an assistant engineer in the Ohio Dept. of Health in 1909, after being graduated from Ohio State University. From 1913 through 1920, he held the position of principal assistant in the engineering firm of R. Winthrop Pratt, and in 1921 he was named county sanitary engineer for Cuyahoga County (Cleveland). He entered private practice in 1925, serving as consulting engineer on water and sewage projects for many municipalities and states, as well as for the United States and Cuban governments and a number of corporations and individuals.

A registered engineer in Ohio and New York, Mr. MacDowell joined AWWA in 1937. His professional affiliations also included the National Society of Professional Engineers and the Federation of Sewage & Industrial Wastes Assns.

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Cosby S. Read, superintendent of the Tuscaloosa, Ala., Water Works Dept. from 1931 until his retirement last year, died in Druid City Hospital May 11, after a lingering illness. Mr. Read, who came to Tuscaloosa from Conyers, Ga., had been with the department since 1912 and was instrumental in modernizing the city's water system.

James McClure Wardle, former superintendent of the Hudson, N.Y., Dept. of Public Works, died suddenly at his home Jul. 9 at the age of 55. A life-long resident of Hudson, Mr. Wardle served 25 years with the Dept. of Public Works, resigning about 5 years ago to become associated with the New York State Parkway Commission. He was a member of the New York Section of AWWA and received the Fuller Award in 1950.

Correction—the table below replaces the one appearing on text page 571 in the June 1955 JOURNAL (see correction notice in the current issue, text page 839).

TABLE 4

Effect of Hydrogen Ion Concentration

Sample pH	Fluoride Error (Positive) *mg/100 ml*
7.0	0.000
6.0	0.000
5.0	0.000
4.5	0.000
4.0	0.002
3.5	0.002
3.0	0.004
2.8	0.006
2.5	0.010
2.2	0.012

Section Meetings

Arizona Section: The Arizona Section and the Arizona Sewage & Water Works Assn. held a joint three-day meeting, Apr. 14–16, at the San Marcos Hotel in Chandler. John Quarty, president of the hotel, was a very genial host. The Arizona Section is very fortunate to have the blonde efficient twins, Olive Hungate and Fern Gray, at the registration desk each year. Represented among the 157 registrants were water company owners; water and sewage plant operators and superintendents; maintenance men; various types of engineers—chemical, sanitary, city, field and construction, and consulting; manufacturer's representatives; university professors; and engineering personnel from nearby Williams Air Force Base.

Thursday, Apr. 14, the address of welcome was given by the Mayor Paul Gaumer of Chandler, who, with his wife, was a guest at all the technical and social gatherings. Phil J. Martin Jr. gave the response. During the morning session the papers presented were: "New Developments in Sewage Works" by Dr. J. A. Montgomery, president, Lakeside Engineering Corp., Chicago; and "Excavation and Backfill," by Andrew Marum, consulting engineer, Tucson, and John T. Young, executive secretary, Central Arizona Concrete Assn.

During the Thursday afternoon session the following papers were presented: "Adult Education" by John C. Park, dean, College of Engineering, University of Arizona; "Lightning Protection for Water and Sewage Works Equipment" by Earl S. Prud'homme, General Electric Co., Tucson; "Proper Liability Insurance Coverage for Utilities" by W. J. McKinnon, manager, Great American Indemnity Co., Los Angeles, and Ralph F. Thompson, insurance and claims supervisor, Arizona Public Service Co., Phoenix. A "No Host Dinner" was held Thursday night.

The Friday morning session began with a very interesting report (supplemented by color slides) on the "New Zealand Sewage Survey," made by A M Rawn, chief engineer and general manager, Los Angeles County Sanitation Dists. Mr. and Mrs. Rawn spent 3 months of last year in New Zealand, where Mr. Rawn collected data for his report. The other papers presented were "Role of Corporation Commission on Water Utilities" by Bernard Brown and "How to Obtain the Friction Coefficient of Existing Pipelines" by Dave Harmon of Headman, Ferguson & Carollo, Engrs., Phoenix.

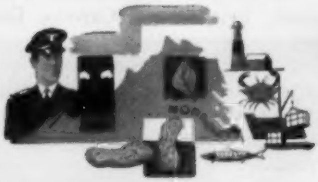
At noon, Friday, a very fine ladies' luncheon and fashion show was held around the beautiful, petunia-bordered swimming pool of the San Marcos. Southwest fashions from the Kachina Shop in the hotel were modeled. A beautiful squaw dress was given to Mrs. Ed Waltenspiel, who held the lucky number at the drawing. The men were invited to attend and came en masse.

During the Friday afternoon session the papers presented were: "Keeping Current With Specifications" by Loring E. Tabor, specification engineer, Los Angeles Dept. of Water & Power; "Ground Water Situation in Arizona" by Samuel F. Turner, consulting geologist and engineer, Phoenix; and "Problems of Tin Pipe Utility" by Spencer D. Stewart, Consolidated Water Co., Phoenix.

Friday night the Association Dinner was held in the Garden Room of the hotel, with ASWWA President Phil J. Martin

(*Continued on page 90 P&R*)

Norfolk Prefers Concrete Pressure Pipe



Since 1921, Norfolk, Virginia, has been specifying concrete pressure pipe for its water supply and distribution system. Over 450,000 feet of pipe is now in use. Diameters range from 20″ to 48″.

Still in excellent condition is the 31,700 feet of concrete pressure pipe laid in 1921. There has been no necessity to take this pipeline out of service for any maintenance work; nor has the pipeline suffered from any trouble due to electrolytic action. This pipe is now carrying water at the same high capacity as when it was installed.

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Section Meetings

(*Continued from page 88 P&R*)

Jr., presiding. Byrl Phelps was master of ceremonies and AWWA Vice-President Frank C. Amsbary Jr. was guest of honor. After the dinner meeting had adjourned, members, wives, and guests were entertained in the hotel by the manufacturers.

During the Saturday morning session the following papers were presented: "Researches on Natural Rainfall" by Dr. A. Richard Kassander Jr., associate director, Institute of Atmospheric Physics, University of Arizona; "Utility Relocation and Alterations" by Frank C. Amsbary Jr. and John A. Carollo, Partner, Headman, Ferguson & Carollo, Engrs., Phoenix.

During the Saturday afternoon session a sewage and water plant operators' roundup was held. Dario Travaini, superintendent of water and sewers, Phoenix, presided over a panel composed of: Quentin Mees, assistant professor of civil engineering, College of Engineering, University of Arizona; Ray A. Drain, superintendent, Sewage Div., Tucson; John Rauscher, hydraulic engineer, Water Dept., Tucson; and Bernard C. Craun, sanitary engineer, State Dept. of Health, Phoenix. The topics discussed were schooling of operators and collection, distribution, and plant problems.

Saturday night a dinner-dance was held in the Garden Room. Phil J. Martin Jr. presided and Walter C. Harford was master of ceremonies. Several skits, poems, essays, and jokes were featured. Phil Martin was presented the George Warren Fuller Award for 1955. A. W. "Dusty" Miller gave Sludge Shovelers Awards to George Martin, Leigh O. Gardner, and Frank C. Amsbary Jr.

After a pleasant evening of dancing, goodnights and goodbyes were said to friends whom the meeting brings together each year for three days of very interesting and informative technical sessions, golf, swimming, bridge, and just plain fun.

QUENTIN M. MEES
Secretary-Treasurer

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Section Meetings

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Pacific Northwest Section: The Pacific Northwest Section, at its 28th annual meeting at the Chinook Hotel, Yakima, Wash., May 19–21, elected C. V. Signor, manager of the Coos Bay–North Bend Water Dept., as its new chairman. The other officers elected were C. R. Harlock (water superintendent, McNeil Island), vice-chairman; C. C. Casad (water superintendent, Bremerton, Wash.), national director; H. C. Clare (director, State Div. of Public Health Eng., Boise, Idaho), Trustee; and Fred D. Jones (distribution supervisor, Spokane Water Dept.), secretary-treasurer. Henry Donnelly (water superintendent, Bellingham, Wash.), the other trustee, was elected in 1954 for a 2-year term.

There were nearly 300 in attendance at the meeting. The 150 ladies were royally entertained by a program arranged by Mrs. Paul Meyer of Walla Walla and Mrs. T. H. Judd of Spokane. A committee of eighteen local ladies, headed by Mrs. Harper Grimes, assisted. The tour of Yakima and its water department, conducted by Harper D. Grimes, the water superintendent, was enjoyed by a large group.

Mayor Gilbert Burns was master of ceremonies at the banquet and also gave the address of welcome at the Thursday noon luncheon. Winston H. Berkeley, outgoing chairman of the section, gave the response. Burns told how important water is to the Yakima Valley and its continued expansion.

Frank C. Amsbary Jr. brought greetings from the national organization and also participated in the technical sessions, giving a paper on the Teays River Valley underground water supply.

Roy E. Morse, formerly water superintendent at Seattle and now with the US Dept. of Interior, Washington, D.C., was chosen to receive the Fuller Award. Ernest C. Willard, consulting engineer, Portland, was given the Powell-Lindsay Citation "for his pioneer work in the organization and development of the Pacific Northwest Section and for his outstanding contribution to the establishment of sound financial programs for water utilities." Ben S. Morrow, manager of the Portland Water Bureau, received a life membership in the Association.

Charles J. Eisenbacker, of the civil defense organization of the State of Washington, told of witnessing the atomic and hydrogen bomb tests at the Nevada proving grounds and discussed radioactive contamination. W. A. Galbraith, director of the Washington Dept. of Conservation & Development, gave a paper on the state's water resources program. Don E. Gray, consulting engineer, Yakima, spoke on the water supply problems in the Columbia Basin area. Amos J. Alter, chief engineer of the Alaska Dept. of Health, gave a talk on cold-weather problems in the territory. Larry Moll, safety engineer, Seattle Water Dept., spoke on the city's safety program, which was started in 1953. A comedy skit entitled "A Morning in the Water Office," by John Berning, Ray Struthers, Tom Judd, Archie Rice, and Robert Duff, was well received.

Fred D. Jones
Secretary-Treasurer

Pennsylvania Section: The seventh annual meeting of the Pennsylvania Section was held May 4–5 at the Webster Hall Hotel, Pittsburgh. This year, instead of the usual 3-day meeting, a 2-day session was tried, and a better meeting resulted, keeping members more interested and together. Nothing suffered for lack of a day.

The program presented was a very good one, beginning Wednesday morning, May 4, with a talk by Richard D. Hoak, senior fellow, Mellon Institute of Industrial Research, Pittsburgh, on "Use and Conservation of Water Resources"; this was followed by a very interesting and timely panel discussion on fluoridation, led by Deputy Attorney-General Robert J. Trace, State Dept. of Health,

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Section Meetings

(Continued from page 92 P&R)

Harrisburg; L. D. Matter, assistant chief engineer, Bureau of San. Eng., State Dept. of Health, Harrisburg, and Dr. Gerald J. Cox, professor of dental research, University of Pittsburgh, participated.

The Wednesday afternoon session began with a description of the treatment plant of the South Pittsburgh Water Co. by C. E. Trowbridge, chief sanitary engineer, American Water Works Service Co., Philadelphia. This talk was followed by a well attended tour of the plant.

Thursday morning's session included papers on: "Algae Control With Chlorine Dioxide," by Walter C. Ringer Jr. and Sylvester Campbell, both of the Bureau of Water, Philadelphia; "Utilization of Waste Pickling Acid in Potable Water Treatment," by J. S. Gettrust, superintendent of water purification and pumping, Akron, Ohio, Water Dept.; "Typhoid in Westmoreland and Allegheny Counties," by Maurice A. Shapiro, assistant professor of sanitary engineering, and Dr. Horace M. Gezon, associate professor of epidemiology, Graduate School of Public Health, University of Pittsburgh.

After the annual luncheon meeting, the concluding session opened with an address by John H. Murdoch Jr., vice-president and counsel, American Water Works Service Co., Philadelphia, followed by an important and very interesting paper by W. Victor Weir, president, St. Louis County Water Co., University City, Mo., on "Air-Conditioning Water Rate Schedules"; the paper was very ably discussed by Gerald E. Arnold, general superintendent, Bureau of Water, Philadelphia, and Wendell R. LaDue, chief engineer and superintendent, Bureau of Water and Sewerage, Akron. The sessions ended with a paper by Martin E. Flentje, research engineer, American Water Works Service Co., on "Research in the Water Works Field."

It is evident that the program committee did a very fine job of arranging a timely, important, and interesting program for the membership. Of course, all was not technical and all was not business. There were lighter moments. The planned activities included a preconvention get-together Tuesday night, sponsored by the manufacturers' association. On Wednesday, the men attended a "Group Interest Luncheon," which was divided into four parts—management, distribution, resources, and purification—and was quite successful. In the afternoon there was golf at the Edgewood Country Club. On Wednesday evening, after a buffet dinner, there was a choice of an exciting baseball game or the social hour, when a "Crazy Hat" contest was held.

Thursday offered the annual luncheon, the usual cocktail hour, and the annual banquet. The Fuller Award nominee was L. D. Matter. Life membership was conferred on A. R. O'Reilly.

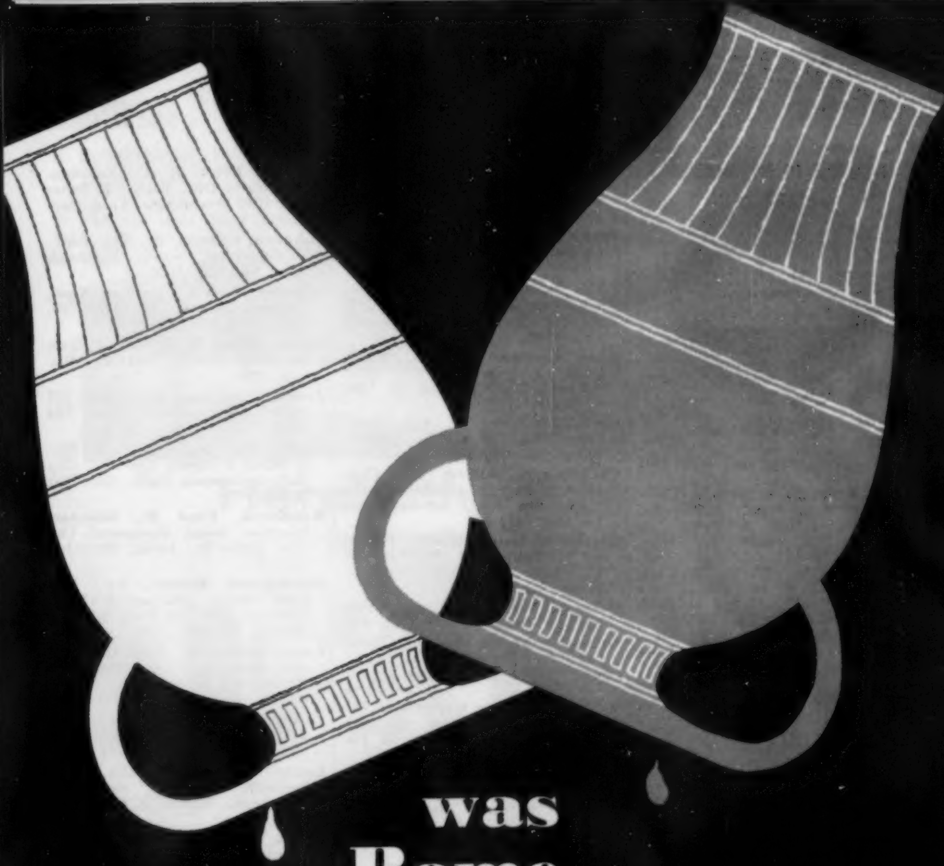
The ladies were not idle. They had practically no time on their hands. The committee headed by Mrs. Joseph F. O'Grady did a fine job in planning activities for the women. On Wednesday there was a dessert social gathering—held at the Pittsburgh Athletic Assn.—which was not only beautiful but very enjoyable. The social hour and the baseball game were open to the ladies, as well as to the men.

On Thursday morning the ladies were able to tour the downtown Pittsburgh area, shopping or seeing the sights. This was followed by luncheon at Kaufmann's and attendance at "Cinerama Holiday."

The business meetings were well attended. Committee reports were given and election of officers took place on Thursday. The new officers for the Section are: Francis S. Friel, chairman; B. French Johnson, vice-chairman; and L. S. Morgan, secretary-treasurer. The trustees are P. W. Miller, for one more year, and J. R. Harvey and P. P. Merkel for 2 years. The new director for the 1956–59 term is L. D. Matter.

The meeting was well planned and well attended and all who came to join in the activities left with many enjoyable memories.

L. S. Morgan
Secretary-Treasurer



CHANGES IN MEMBERSHIP

NEW MEMBERS

Applications received July 1–31, 1955

Anaya y Sorribas, Manuel, Chief, Div. of Water Supply & Sewerage, Ministry of Hydr. Resources, Mar Jonico 22, Mexico 17, D.F., Mexico (Jul. '55)

Ashland, City of, Paul L. Chorpening, Director of Public Service & Safety, City Bldg., Ashland, Ohio (Munic. Sv. Sub. Jul. '55)

Barker, Richard, Sr., Secy.-Treas., Lafourche Parish Water Dist. No. 1, Lockport, La. (Jul. '55) *M*

Beloit, City of, Collins G. Fort, Supt. of Light & Water, Beloit, Kan. (Corp. M. Jul. '55) *MRP*

Berglund, William K., Dist. Mgr., Fischer & Porter Co., 238 E. Sorsyth St., Jacksonville, Fla. (Jul. '55) *P*

Boyer, Edward S., Director of Sales, Welsbach Corp., Kitson Valve Div., Westmoreland & Stokley Sts., Philadelphia 29, Pa. (Jul. '55) *D*

Burns, John Thomas, Dist. Sales Engr., Electro Rust Proofing Corp., 1 Main St., Belleville, N.J. (Jul. '55) *MD*

Busse, Wilbur E., Contracting Engr., Chicago Bridge & Iron Co., 1412 C & I Life Bldg., Houston 2, Tex. (Jul. '55) *D*

Chorpening, Paul L.; *see* Ashland (Ohio)

Congleton, Harry R., Water Supt., Grand Rapids, Ohio (Jul. '55)

Curtis, Edgar H., Estimator, American Pipe & Constr. Co., 4635 Firestone Blvd., South Gate, Calif. (Jul. '55) *RD*

Custer, Joseph W., Mgr., Vera Irrigation Dist. No. 15, 601 N. Evergreen, Veradale, Wash. (Jul. '55) *MD*

Delaware, Public Service Com. of, W. Rodney Price, Exec. Secy., Old State House, Dover, Del. (Corp. M. Jul. '55) *MRP*

DeLonge, Harry C., Water Technician, Pepsi Cola Co., 3 W. 57th St., New York, N.Y. (Jul. '55) *P*

Dempsey, W. T., Cons. Engr., 37 King St. E., Oshawa, Ont. (Jul. '55)

Doell, Harry A., Western Dist. Mgr., S. Morgan Smith Co., 68 Post St., Rm. 315, San Francisco 4, Calif. (Jul. '55) *RPD*

Dornblatt, Bernhard M., Pres., B. M. Dornblatt & Assocs., Inc., 820 Carondelet Bldg., New Orleans 12, La. (Jul. '55) *RP*

Flynn, Thomas F., Chem. Engr., Calgon, Inc., 1516 Locust St., Philadelphia 2, Pa. (Jul. '55) *P*

Fort, Collins G.; see Beloit (Kan.)

Frey, Clifton A., Owner, C. A. Frey & Assocs., 1010 Creswell, Shreveport, La. (Jul. '55) *RP*

Gard, George W., Mgr., Munic. Sales, Fischer & Porter Co., 16511 Kinsman Rd., Cleveland 20, Ohio (Jul. '55) *MPD*

Gerber, Robert A., Asst. Engr., State Board of Health, Jackson, Miss. (Jul. '55) *MRP*

Goehringer, Alfred E., Chief Mech. Engr., Swindell-Dressler Corp., Box 1888, Pittsburgh 30, Pa. (Jul. '55) *PD*

Greenfield Water Works, Thomas D. Peterson, Plant Operator, 706 E. Main St., Greenfield, Ind. (Corp. M. Jul. '55) *MP*

Gregory, Edwin L., Water Works Design, Vancouver, B.C. (Jul. '55)

Gubanich, John A., Secy.-Treas., General Waterworks Corp., 1500 Walnut St., Philadelphia 2, Pa. (Jul. '55) *M*

Guilford-Chester Water Co., Edward P. Williams, Pres., W. Main St., Clinton, Conn. (Corp. M. Jul. '55) *MRPD*

Hamilton, Hugh L.; *see* Smith, A. V., Eng. Co.

Hardy, William Ralph, San. Engr., Public Health Dept., City Hall, Fort Worth, Tex. (Jul. '55) *M*

Harris, William S., Distr. Engr., American Water Works Service Co., Inc., 3 Penn Center Plaza, Philadelphia 2, Pa. (Jul. '55) *MD*

Heffernan, Joseph J., Project Engr., M. M. Dillon & Co., Ltd., 141 Maple St., London, Ont. (Jul. '55)

Herring, J. E., Water Supt., Denver City, Tex. (Jul. '55) *M*

Hill, Charles E., Supt., Water Dept., Lakin, Kan. (Jul. '55) *MRP*

Hills, Frederick, Comr., Utilities Com., Peterborough, Ont. (Jul. '55)

Holden, Loyle C., Civ. Engr., Southern California Div., American Pipe & Constr. Co., 4635 Firestone Blvd., South Gate, Calif. (Jul. '55) *MRPD*

Huey, Stanton E., Cons. Engr., S. E. Huey & Co., Heninger Bldg., Monroe, La. (Jul. '55) *RP*

Hunter, Fred, Jr., Sales Repr., Price Brothers Co., 5853 Pointer Lane, Cincinnati 13, Ohio (Jul. '55) *D*

Indio, City of, Thomas E. Selman, Director of Public Works, City Offices, Indio, Calif. (Munic. Sv. Sub. Jul. '55)

Jackson, Thomas M., Jr., Product Mgr., Celite Div., Johns-Manville Product Corp., 22 E. 40th St., New York 16, N.Y. (Jul. '55) *P*

Jarratt, Peter R. C., Salesman, Chlorinator Div., Fischer & Porter Co., 5010 Woodminster Lane, Oakland 2, Calif. (Jul. '55) *RP*

Johnson, Clinton W., Gen. Supt., Utility Plant Board, Morehead, Ky. (Jul. '55) *MD*

Johnson, Neil R., Maritime Repr., Neptune Meters Ltd., Box 984, Halifax, N.S. (Jul. '55)

Jones, Henry M., San. Engr., State Board of Health, Jackson, Miss. (Jul. '55)

Jones, John, Asst. City Engr., 177 "D" St., Upland, Calif. (Jul. '55) *MD*

Jones, Ray W., Asst. Supt., Div. of Water & Sewers, Rm. 111, City Hall, Sacramento, Calif. (Jul. '55) *MRPD*

Kauffman, Fred M., Salesman, Sebastian Diesel Equipment Co., 1801 Joplin St., Joplin, Mo. (Jul. '55) *M*

Kimbrough, Robert, Mgr., Pipe Sales, Armco Drainage & Metal Products, Inc., 619 Forsyth Bldg., Atlanta, Ga. (Jul. '55)

Laux, Robert P., Town Classification Inspector, Ohio Inspection Bureau, 431 E. Broad St., Columbus 16, Ohio (Jul. '55) *MD*

Lefort, Norman C., Office Mgr., Lafourche Parish Water Dist. No. 1, Lockport, La. (Jul. '55) *M*

Lewis, Calvin O., Sales Engr., Rockwell Mfg. Co., 4669 Columbine St., Denver 16, Colo. (Jul. '55) *MP*

Lyons, Helen L. (Miss), Supervisor, Water Plant, Rte. 1, Box 926, Sarasota, Fla. (Jul. '55) *P*

MacKichan, Kenneth A., Hydr. Engr., US Geological Survey, Washington 25, D.C. (Jul. '55)

Masterson, John M., Repr., Glamorgan Pipe & Foundry Co., Peoples Gas Bldg., Chicago, Ill. (Jul. '55)

Mauro, Joseph L., Jr., Supt. of Water & Sewers, 710 Bangs Ave., Asbury Park, N.J. (Jul. '55) *MRPD*

McCain, John I., Civ. Engr., McCain & Assocs., 8200 Florida St., Baton Rouge, La. (Jul. '55) *PD*

McClean, George T., Civ. Engr., 255 Kensington Ave., Astoria, Ore. (Jul. '55) *D*

Meslin, Jerry, Mgr., Morningside Pool, 850 N.E. 55th Terrace, Miami, Fla. (Jul. '55) *P*

Milbridge Water Co., William F. Sawyer, Pres., Milbridge, Me. (Corp. M. Jul. '55) *MD*

Miller, Billy R., Mgr., Harris County Water Control & Improvement Dist. No. 39, 9508 Compton, Box 11142, Houston 16, Tex. (Jul. '55) *M*

Morgan, Thomas M., Civ. Engr., United Water Conservation Dist., 806 Railroad Ave., Santa Paula, Calif. (Jul. '55)

Moser, Russell J.; *see* Plymouth (Ohio) Board of Public Affairs

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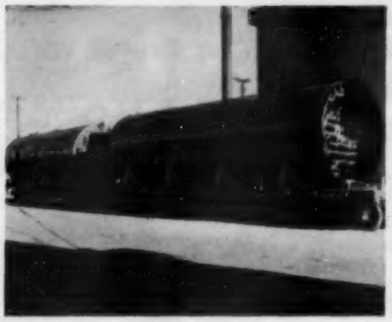

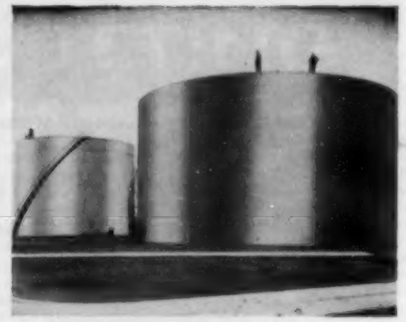

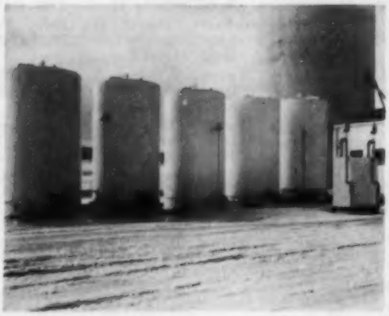

(Continued from page 96 P&R)

Munz, Charles F., Salesman, Welsbach Corp., Kitson Valve Div., Westmoreland & Stokley Sts., Philadelphia 29, Pa. (Jul. '55) *D*

Nasir, Jamil Ahmed, Mgr., Jerusalem Water Supply, c/o Municipality, Jerusalem, Hashimite, Jordan (Jul. '55)

Nelson, Waldemar S., Partner, Bedell & Nelson, 840 Union St., New Orleans 12, La. (Jul. '55) *PD*

O'Day, Joseph D., Gen. Mgr., New York Water Service Corp., Rochester Div., 20 East Ave., Rochester 4, N. Y. (Jul. '55) *MRPD*

Ohge, Harry C., Mfer.'s Repr., Hungerford & Terry Co., 5324 Primrose Ave., Indianapolis, Ind. (Jul. '55)

Peterson, Russell J., Engr., Henningson-Durham-Richardson Inc., 2962 Harney St., Omaha 2, Neb. (Jul. '55) *P*

Peterson, Thomas D.; *see* Greenfield (Ind.) Water Works

Petrea, Clifton J., Water Supt., Village of Lake Worth, Rte. 11, Box 174 B, Fort Worth 14, Tex. (Jul. '55)

Plymouth Board of Public Affairs, Russell J. Moser, Plymouth, Ohio (Munic. Sv. Sub. Jul. '55)

Pounds, Archie, Com. of Streets & Parks, City Hall, Bogalusa, La. (Jul. '55) *MR*

Price, W. Rodney; *see* Delaware, Public Service Com. of

Quigley, Joseph A., Supt., National Water Main Cleaning Co., 3605—65th Ave., Landover Knolls, Hyattsville, Md. (Jul. '55)

Reid, James H., Cons. Engr., James H. Reid & Assocs., 420 Bell St., Edmonds, Wash. (Jul. '55) *RPD*

Robinson, Joe W., Water Supt., Box 683, Dayton, Tex. (Jul. '55) *M*

Rogers, George E., Northside Sewer Plant, 7511 Hillsboro St., Houston 20, Tex. (Jul. '55) *M*

Saldivia, Juan V., Chief Civ. Engr., Las Vizcachas Filter Plant, Ave. General Bulnes 129, Santiago, Chile (Jul. '55) *P*

Saunders, William K., C & C Construction Co., 2001 E. Pontiac St., Fort Wayne, Ind. (Jul. '55)

Savoy, Walter, Works Foreman, Munic. Water & Sewers, Dalhousie, N.B. (Jul. '55)

Sawyer, William F.; *see* Milbridge (Me.) Water Co.

Scherer, Clarence H., Supervising Chemist, Water Reclamation & Sewage Treatment Plant, City Auditorium, Amarillo, Tex. (Jul. '55) *MRP*

Selman, Thomas E.; *see* Indio (Calif.)

Sherborne, John E., Mgr., Production Research Div., Union Oil Co. of California, Box 218, Brea, Calif. (Jul. '55) *P*

Shifrin, Walter G., 23 Hillvale Dr., Clayton 5, Mo. (Jr. M. Jul. '55)

Simmons, Dale O., Filter Plant Operator, 2555 Van Alstyne, Wyandotte, Mich. (Jul. '55) *P*

Smith, A. V., Eng. Co., Hugh L. Hamilton, Pres., Essex Bldg., Narberth, Pa. (Corp. M. Jul. '55) *D*

Snyder, Henry Philip, Asst. Civ. Engr., Water Dept., 597 S. Thomas St., Pomona, Calif. (Jul. '55) *D*

Sommer, Adam, Application Engr., Alco Products, Inc., 415 Robin St., Dunkirk, N.Y. (Jul. '55) *D*

Stanley, John H., Gen. Supt., Goodland, Kan. (Jul. '55) *MRD*

Stott, William Russell, Sales Mgr., Welsbach Corp., Kitson Valve Div., Westmoreland & Stokley Sts., Philadelphia 29, Pa. (Jul. '55) *D*

Swanson, Robert W., Supt., Richland Water Dist., 1940 N.E. 137th St., Portland 20, Ore. (Jul. '55) *MD*

Syrkin, Simon, Cons. Engr., 94 Alenby Rd., Tel Aviv, Israel (Jan. '55) *MRPD*

Tatum, W. M., Jr., Supt., Water Dept., Box 447, Newellton, La. (Jul. '55) *MP*

Teckoe, J. E., Jr., Gen. Mgr., Utilities Com., Windsor, Ont. (Jul. '55)

Thomas, Hal M., Sales Repr., Pacific States Cast Iron Pipe Co., 501-2 Portland Trust Bldg., 319 S.W. Washington St., Portland 4, Ore. (Jul. '55) *D*

Tyrer, Gene A., Salesman, General Chem. Div., 3357 W. 47th Pl., Chicago 32, Ill. (Jul. '55) *P*

Vandertill, James C., Sales Repr., Olin Mathieson Chem. Corp., 900 Dixie Terminal Bldg., Cincinnati 2, Ohio (Jul. '55) *P*

Vaughn, L. G., Engr., Hemphill Pumping Sta., 1210 Hemphill Ave., N.W., Atlanta 13, Ga. (Jul. '55) *P*

Volkert, David G., Pres., Ewin Eng. Corp., Box 361, Mobile, Ala. (Jul. '55) *MR*

Walsh, William C., Jr. Partner, Dannenbaum-Walsh, Box 1066, Angleton, Tex. (Jul. '55) *R*

Watson, Donald C., Mgr., Constr. Div., Turbine Equipment Co., Box 578, Westfield, N.J. (Jul. '55) *MD*

Weck, Herman F., Asst. Mgr., Downey County Water Dist., 8348 E. 2nd St., Downey, Calif. (Jul. '55) *MP*

Weikel, Robert C., Weikel Constr. Inc., Box 1108, Fort Wayne, Ind. (Jul. '55) *D*

Welch, Marion C., San. Engr., 4003 Frankfort Ave., Louisville 7, Ky. (Jul. '55) *MRP*

West, Maurice C., Mayor, City Hall, Graysville, Ala. (Jul. '55) *M*

White, John W. L., Engr., Consumers Water Co., 95 Exchange St., Portland, Me. (Jul. '55) *MRPD*

Williams, Bertram F., Mgr., Arlington Water Works, Box 846, Jacksonville 11, Fla. (Jul. '55) *M*

Williams, Edward P.; *see* Guilford-Chester (Conn.) Water Co.

Witzgall, John S., Navy 3080, Box 4 FPO, San Francisco, Calif. (Jul. '55) *MPD*

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Blockson Chemical Co.

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Mueller Co.
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Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Meters, Filtration Plant, Pumping Station, Transmission Line:
Builders-Providence, Inc.
Fischer & Porter Co.
Foster Eng. Co.
Infilco Inc.
Penn Industrial Instrument Div.
Simplex Valve & Meter Co.

Meters, Industrial, Commercial:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Builders-Providence, Inc.
Fischer & Porter Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Simplex Valve & Meter Co.
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Mixing Equipment:
Chain Belt Co.
General Filter Co.
Infilco Inc.

Paints
Inertol Co., Inc.

Pipe, Asbestos-Cement:
Johns-Manville Corp.
Keasbey & Mattison Co.

Pipe, Brass:
American Brass Co.

Pipe, Cast Iron (and Fittings):
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Pipe, Cement Lined:
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
United States Pipe & Foundry Co.
R. D. Wood Co.

Pipe, Concrete:
American Concrete Pressure Pipe Assn.
American Pipe & Construction Co.
Lock Joint Pipe Co.

Pipe, Copper:
American Brass Co.

Pipe, Steel:
Armco Drainage & Metal Products, Inc.
Bethlehem Steel Co.

Pipe Coatings and Linings:
The Barrett Div.
Cast Iron Pipe Research Assn
Centriline Corp.
Inertol Co., Inc.
Koppers Co., Inc.
Reilly Tar & Chemical Corp.

Pipe Cutters
James B. Clow & Sons
Ellis & Ford Mfg. Co.
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.
Spring Load Mfg. Corp.

Pipe Jointing Materials; see Jointing Materials

Pipe Locators:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Pipe Vises
Spring Load Mfg. Corp.

Plugs, Removable:
James B. Clow & Sons
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Potassium Permanganate
Carus Chemical Co.

Pressure Regulators:
Allis-Chalmers Mfg. Co.
Foster Eng. Co.
Mueller Co.
Ross Valve Mfg. Co.

Pumps, Boiler Feed:
DeLaval Steam Turbine Co.

Pumps, Centrifugal:
Allis-Chalmers Mfg. Co.
American Well Works
DeLaval Steam Turbine Co.
Morse Bros. Mchy. Co.
C. H. Wheeler Mfg. Co.

Pumps, Chemical Feed:
Infilco Inc.
Proportioneers, Inc.
Wallace & Tiernan Inc.

Pumps, Deep Well:
American Well Works
Layne & Bowler, Inc.

Pumps, Diaphragm:
Dorr-Oliver Inc.
Morse Bros. Mchy. Co.

Pumps, Hydrant:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Pumps, Hydraulic Booster:
Ross Valve Mfg. Co.

Pumps, Sewage:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
C. H. Wheeler Mfg. Co.

Pumps, Sump:
DeLaval Steam Turbine Co.
C. H. Wheeler Mfg. Co.

Pumps, Turbine:
DeLaval Steam Turbine Co.
Layne & Bowler, Inc.

Recorders, Gas Density, CO_2, NH_3, SO_2, etc.:
Fischer & Porter Co.
Permutit Co.
Wallace & Tiernan Inc.

Recording Instruments:
Fischer & Porter Co.
Infilco Inc.
Penn Industrial Instrument Div.
Wallace & Tiernan Inc.

Reservoirs, Steel:
Chicago Bridge & Iron Co.
Graver Water Conditioning Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Sand Expansion Gages; see Gages

Sleeves; see Clamps

Sleeves and Valves, Tapping:
James B. Clow & Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Sludge Blanket Equipment:
General Filter Co.
Graver Water Conditioning Co.
Permutit Co.

Sodium Hexametaphosphate:
Blockson Chemical Co.
Calgon, Inc.

Sodium Silicate
Philadelphia Quartz Co.

Softeners:
Cochrane Corp.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Softening Chemicals and Compounds:
Calgon, Inc.
Cochrane Corp.
General Filter Co.
Infilco Inc.
Morton Salt Co.
Permutit Co.
Tennessee Corp.

Standpipes, Steel:
Chicago Bridge & Iron Co.
R. D. Cole Mfg. Co.
Graver Water Conditioning Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
R. D. Cole Mfg. Co.
Graver Water Conditioning Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Stops, Curb and Corporation:
Hays Mfg. Co.
Mueller Co.

Storage Tanks; see Tanks

Strainers, Suction:
James B. Clow & Sons
M. Greenberg's Sons
Johnson, Edward E., Inc.
R. D. Wood Co.

Surface Wash Equipment:
Cochrane Corp.
Permutit Co.

Swimming Pool Sterilization:
Fischer & Porter Co.
Omega Machine Co. (Div., B-I-F Industries)
Proportioneers, Inc.
Wallace & Tiernan Inc.

Tanks, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
R. D. Cole Mfg. Co.
Graver Water Conditioning Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Tapping-Drilling Machines:
Hays Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.

Tapping Machines, Corp.:
Hays Mfg. Co.
Mueller Co.

Taste and Odor Removal:
Cochrane Corp.
Fischer & Porter Co.
General Filter Co.
Graver Water Conditioning Co.
Industrial Chemical Sales Div.
Infilco Inc.
Permutit Co.
Proportioneers, Inc.
Wallace & Tiernan Inc.

Tenoning Tools
Spring Load Mfg. Corp.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Wallace & Tiernan Inc.

Turbines, Steam:
DeLaval Steam Turbine Co.

Turbines, Water:
DeLaval Steam Turbine Co.

Valve Boxes:
James B. Clow & Sons
Ford Meter Box Co.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
Trinity Valley Iron & Steel Co.
R. D. Wood Co.

Valve-Inserting Machines:
Mueller Co.
A. P. Smith Mfg. Co.

Valves, Altitude:
Ross Valve Mfg. Co., Inc.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
Chapman Valve Mfg. Co.
James B. Clow & Sons
DeZurik Shower Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Henry Pratt Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Valves, Float:
James B. Clow & Sons
Henry Pratt Co.
Ross Valve Mfg. Co., Inc.

Valves, Gate:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Dresser Mfg. Div.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
DeZurik Shower Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Henry Pratt Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Regulating:
DeZurik Shower Co.
Foster Eng. Co.
Mueller Co.
Henry Pratt Co.
Ross Valve Mfg. Co.

Valves, Swing Check:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Venturi Tubes
Penn Industrial Instrument Div.

Waterproofing
Inertol Co., Inc.

Water Softening Plants; see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
Wallace & Tiernan Inc.

Water Treatment Plants:
Allis-Chalmers Mfg. Co.
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Cochrane Corp.
Dorr-Oliver Inc.
Fischer & Porter Co.
General Filter Co.
Graver Water Conditioning Co.
Hammond Iron Works
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.

Well Drilling Contractors:
Layne & Bowler, Inc.

Well Screens
Johnson, Edward E., Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite; see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1953 AWWA Directory.